STANDARD VALUES *in* NUTRITION *and* METABOLISM

Being the second fascicle of a Handbook of Biological Data

EDITED BY

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Foreword

Five years ago the National Academy of Sciences-National Research Council contracted with the Wright Air Development Center United States Air Force, to gather and compile for publication the more basic established data in the various fields of biological science The present work issued in August, 1954 under joint sponsorship of the Air Force Army Navy and Atomic Energy Commission as Wright Air Development Center Technical Report 52-301, is the second fascicle* resulting from the project

Direction of the work was entrusted to the Committee on the Handbook of Biological Data an organ of the American Institute of Biological Sciences The Institute is affiliated with the National Research Council as a unit in the Council's Division of Biology and Agriculture Membership of the Committee is representative of major fields in plant and animal biology

Seeking highest degree of authoritativeness for the work the Committee recognized that specialists in a field from which a table is drawn can best exercise the critical judgment necessary to evaluate and select data for an authoritative table The specialist can best identify those data born of most acceptable methods of measurement and those having greatest likelihood or actual history of reproducibility in competent hands The Committee accordingly prescribed that in selection and review of data broadest collaboration be sought among investigators in nutrition metabolism and related fields

This monograph is the product of contributions of more than 800 specialists in these fields in this country and abroad Its 160 tables as originally compiled were subjected to extensive review by experts in the respective subjects By this procedure it has been possible to strip from the tables most of the controversial or questionable or borderline material leaving for final presentation to the user only what is presently accepted as fact by those who are competent to judge The 223 pages of tables and 16 pages of diagrams contain many thousands of items of authoritative data--mostly quantitative but with important non-numerical exceptions The task of culling and condensing the mass of data on hand to conform with time and space limitations has been gigantic It is planned that much that has been so eliminated will be published in subsequent fascicles or in the final Handbook of Biological Data.

Acknowledgment is made on behalf of the Committee to Wright Air Development Center Office of the Surgeon General of the Army Office of Naval Research and Division of Biology and Medicine Atomic Energy Commission for the foresight and scientific judgment inherent in the commission to prepare this tabular monograph; to the biologists of this and other countries whose generous devotion of time as contributors and reviewers has made possible completion of the work as it stands and to many others unlisted who have given the Committee solicited advice Acknowledgment is also made to present and former members of the Handbook Staff for their loyalty and devotion to a most tedious and exacting job

*The first Standard Values in Blood was published in 1952 Others in progress deal with the fields of growth and reproduction animal and plant physiology biochemical composition and toxicology An abridged Handbook of Biological Data containing tabular information drawn from all areas of biological science is also in preparation



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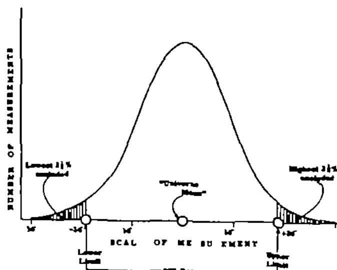
Introduction

This volume presents tabular data and certain charts and graphs in the general field of nutrition and metabolism Both plant and animal forms are included The guiding principle in selecting material has been that it be of basic importance in its general field; ready availability elsewhere has not been regarded as a reason for excluding it

Some material of fundamental importance has had to be omitted either because efforts to secure the needed data have not succeeded or because time has not permitted the necessary steps for getting available data into print. Inability to publish material that a contributor may have spent many hours in compiling is cause for the deepest regret. Such unused material will it is hoped be the source of valuable additional tables when this volume is revised

In the preparation of material in tabular form the chief objective has been clarity of presentation Where the subject matter of a table has been considered to be inherently difficult for the non-specialist -- the beginning student in the subject or the specialist in another field -- effort has been made in explanatory headnotes and footnotes to resolve for the reader some of the difficulty Footnotes have also been used in many instances for information originally within the table itself where simplification of the structure of the table could be achieved by withdrawal of the information into the footnotes

In each instance where a numerical value is given for a variable the value is the mean (or adjusted mean) of a group of measured values Where possible to obtain each such value is followed by an estimate of the lower and upper limits of the 95% range The 95% range has been selected in preference to the standard deviation as better suited to the needs of the reader who is not a specialist in the field from which a value has been drawn The 95% range is a direct representation of the ordinary* range of variation to be had only by further calculation if the standard deviation alone is available The latter has the disadvantage of not being readily available in many instances and of giving biased limits for the 95% range when a variable has a skewed distribution The statistically-minded reader who might wish to make further calculations from values in these tables will not care to proceed without information on comparability and number of measurements Unfortunately space does not permit including here such collateral information but the bibliographic references will lead to the original data where it should be found.



The 95% range may be estimated in several ways the method depending on the information available The types of estimate most commonly encountered are listed below The letter designations (a b c d) will be found as identifying superscripts opposite ranges given in the tables (For details of these and other estimates see texts on statistical methods)

*To the clinician equivalent, with reservations to normal and borderline

ange data as commonly encountered including estimates of the 95% range represent a ixture of the variability existing between individuals and the variability existing within dividuals

(a) By the method of greatest accuracy the 95% range is obtained by fitting a recog zed type of frequency curve to a group of measured values and excluding the extreme 5% of area under the curve at each end (See sketch on preceding page) Estimate is ade by this procedure only when the group of values is relatively large

(b) By a less accurate method the 95% range is estimated by a simple statistical alculation assuming a normal distribution and using the standard deviation This esti-ate is used when the group of values is too small for curve fitting as is usually the case

(c) A third and still less accurate procedure for estimate of the 95% range is sim y to take as range limits the highest value and lowest value of the reported sample group measurements It underestimates the 95% range for small samples (3 or 4 values) and verestimates for larger sample sizes but may be used in preference to the preceding ethod when the sample shows convincing evidence that the variable is asymmetrical in stribution

(d) The upper and lower limits of the ordinary range of variation as estimated by n investigator experienced in measuring the quantity in question and based solely on gen ral experience constitute still another estimate of the 95% range The trustworthiness limits so placed should not be underestimated.

In many instances range data have not been available In other instances an esti ate of the 95% range is given but information on the manner of estimate is lacking Ef-ort to assemble both types of missing information is continuing

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The data in each table are in the judgment of the contributors and reviewers es-ablished fact and free of questionable material and represent the consensus of expert udgment and experience in the special field from which the table was drawn. It is recog ized however that all data are subject to continuing revision as investigators improve echniques and make more measurements The reader is warned against attributing sig-ificance to small differences from species to species He is invited to submit any values r ranges he feels should be given consideration and is particularly invited to add to the overage of animal and plant forms

TABLES

1 NUTRIENTS THE CHEMICAL ELEMENTS

If an organism cannot achieve typical growth health or reproduction in the absence of an element the element is listed as R (or r) If addition of an element not required improves growth health or reproduction the element is listed as s Accumulation in the tissues of an organism is not alone taken as sufficient evidence of requirement Characterizations are subject to change with further study and increasing purity of materials In particular r may become R and R̸ may become R or r

R = Required by all forms studied; R̸ = Not required by any forms studied; r = Required by one or more species or strains; u= = Utilized as effectively, replaces wholly or is interchangeable with another element for one or more species or strains; u< = Can partially replace or spare another element for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; a = Accumulated in the tissues of one or more forms; c = Commonly present in the food of some forms and in the tissues at similar concentrations but requirement is uncertain

Groups of Organisms / Nutrient Element	Plants						Animals			
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1 Aluminum	r s a	R̸	R̸	R̸ u<[4]	R̸	R̸	R̸	R̸		R̸
2 Arsenic	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸	a	R̸
3 Boron	R	R̸ s	R̸	r	r	r?	R̸	R̸	R̸	R̸
4 Bromine	R̸	R̸	R̸	R̸	R̸ a	R̸	R̸	R̸	r? [5]a?	R̸
5 Calcium	R	r s a	r u=[6]	r s	R	r	R	r c	r	R
6 Carbon[7]	R	R	R	R	R	R	R	R	R	R
7 Chlorine	r s	R̸	R̸	R̸	a	R̸	R̸	r c	r	R
8 Chromium	R̸	R̸	R̸	u=[8]	R̸	R̸	R̸	R̸		R̸
9 Cobalt	r	r	u=[6]	r	r	r	r	r? s?		r
10 Copper	R	R	r	r u<[4]	r		r	r c	r	r
11 Fluorine	R̸ a	R̸	R̸	R̸	R̸	R̸	R̸	R̸	a	R̸ s
12 Gallium	r	r s	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
13 Hydrogen[7]	R	R	R	R	R	R	R	R	R	R
14 Iodine	R̸ s	R̸	R̸ s	R̸ s	R̸ a	R̸	R̸	R̸	r? a	R
15 Iron	R	R	R	r u<[4]	R	R	R	R	r	R

/1/ Spermatophytes (the intact plant) /2/ = Green phytoflagellates chrysomonads dinoflagellates /3/ Including the colorless phytoflagellates /4/ u< Mn or Cr for Aerobacter aerogenes /5/ Occurs in scleroprotein of certain corals as di-bromotyrosine /6/ u= Ca in yeast cocarboxylase /7/ Universal constituents of protoplasm /8/ u= Mn for Aerobacter aerogenes

1 NUTRIENTS THE CHEMICAL ELEMENTS (Concluded)

If an organism cannot achieve typical growth health or reproduction in the absence of an element the element is listed as R (or r) If addition of an element not required improves growth health or reproduction the element is listed as s Accumulation in the tissues of an organism is not alone taken as sufficient evidence of requirement Characterizations are subject to change with further study and increasing purity of materials In particular r may become R and R̸ may become R or r

R = Required by all forms studied; R̸ = Not required by any forms studied; r = Required by one or more species or strains; u = Utilized as effectively replaces wholly or is interchangeable with another element for one or more species or strains; u< = Can partially replace or spare another element for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; a = Accumulated in the tissues of one or more forms; c = Commonly present in the food of some forms and in the tissues at similar concentrations but requirement is uncertain

	Groups of Organisms / Nutrient Element	Plants						Animals			
									Invertebrates		
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
16	Magnesium	R	R	R	r	R	R	R	R	R	R
17	Manganese	R	r s	r u=[6]	r u=	r	r	r	r c a	r[9]	R
18	Molybdenum	R a	R [10] s	r	r[10]	r[10]	R̸	R̸			r[11]
19	Nitrogen[7]	R	R	R	R	R	R	R	R	R	R
20	Oxygen[7]	R	R	R	R	R	R	R	R	R	R
21	Phosphorus[7]	R	R	R	R	R	R	R	R	R	R
22	Potassium	R	R	r	r	R a	R	R	r c a	R	R
23	Rubidium	R̸	R̸	R̸	u=[12]	R̸	R̸	R̸	R̸		R̸
24	Selenium	R̸ a	R̸	R̸	R̸	R̸	R̸	R̸	R̸		R̸
25	Silicon	r	R̸	R̸	R̸	R̸	r	r	R̸	r	R̸
26	Sodium	r? s a	R̸	R̸	r	r a	R̸	r	r? c		R
27	Strontium	R̸	R̸	R̸	u=[13]	R̸ u=	R̸	R̸	R̸		R̸
28	Sulfur[7]	R	R	R	R	R	R	R	R	R	R
29	Tungsten	R̸	s	R̸	R̸	R̸	R̸	R̸	R̸		R̸
30	Vanadium	R̸	R̸ s	R̸	u<[14]	r	R̸	R̸ s?	R̸	r[15]	R̸
31	Zinc	R	R	r	r u=	r	r	r	r	r? a	R

/1/ Spermatophytes (the intact plant) /2/ = Green phytoflagellates chrysomonads dinoflagellates /3/ Including the colorless phytoflagellates /6/ u Ca in yeast cocarboxylase /7/ Universal constituents of protoplasm. /9/ In blood respiratory pigment of Pinna squamosa (mollusk) /10/ R for NO_3 utilization by some fungi and some algae; R for N_2 fixation by some bacteria and algae /11/ "Xanthine oxidase factor /12/ u= Ca by some /13/ u= Ca by Azotobacter /14/ u< Mo in N_2 fixation /15/ In blood pigment of certain tunicates (Chordata)

2 NUTRIENTS ESSENTIAL ORGANIC COMPOUNDS AMINO ACIDS PEPTIDES PROTEINS

Requirement depends on inability of an organism to synthesize a needed molecular structure Amino acids not known to be required from the environment by any organism, e g hydroxyproline iodogorgoic norleucine ornithine thyroxine are omitted No distinction between dextro- and laevo-isomers is made although they are not in many cases nutritionally equivalent It is noteworthy that in one concentration an amino-acid may support good growth in another concentration inhibit or be toxic When requirement and utilization are noted together it is to be understood that at least one member of a group requires the amino-acid specifically other members do not require but utilize it as a general nitrogen source for energy or synthesis of other compounds Only needs of intact organisms are considered

R Required by all forms studied; R̸ Not required by any form studied; r Required by one or more species or strains; rm Required by one or more mutants; U Utilized as a source of nitrogen and/or carbon by all forms studied although not a specific requirement for all; u Utilized by one or more species or strains as source of nitrogen and/or carbon although not a specific requirement;* Replaces effectively one or more other amino-acids one of the interchangeable seri s being required in the diet; ụ̸ Not utilized by one or more species or strains; s Stimulates growth or other processes for one or more species or strains; Serves as complete nitrogen source for one or more speci or strains; **Serves as simplest complete nitrogen source for one or more species or strains

Groups of Organisms / Nutrient	Plants						Animals			
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Invertebrates: Insects	Invertebrates: Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1 Organic N (per se)	R̸ u*	r rm u*[4]	r rm u*[4]	r u*[4]	R̸ u*	r u*	r,U*	R,U*	R	R,U*
2 Proteins (per se)	R̸	R̸ u*	R̸ u*	R̸ u*	R̸	u	r[5] u*	R̸[6] s U*	U	R̸[6] s U*
3 Polypeptides[7] peptones	R̸ u*	R̸ u*	R̸ u*	r,u*[8]	R̸ u*	u[9] u*	r,u*	R̸		R̸ U
4 Amino acids	R̸ u*[10]	r rm u*	rm u*[11]	r[12] rm u*	R̸ u*[13]	r u[9] u*[14]	r[15] u*	R U**		R U**
Amino Acids										
5 Alanine	R̸ u*	u* u[16]	u*	r u*	R̸ u*	R̸ u*	u	r[17] u		R̸ U
6 Arginine	R̸ u*	rm u*	rm,u*	r rm u*	R̸ u*	R̸ u*	r[18] s u	r[17]		r[19] U
7 Aspartic acid[20]	R̸ u*	u* u[16]	u*	r u*	R̸ u*	r u*	u s	r[17] ụ̸		R̸ U
8 Citrulline	R̸	rm u*		r u*	R̸		u	r u		R̸ u[21] U
9 Cysteine	R̸ u*	rm u*	u*	r u*	R̸,u*		u	r,u*		R̸ U
10 Cystine	R̸ u*	rm u*	u*	r rm u*	R̸		u	r[17] u		R̸ U
11 Glutamic acid[20]	R̸ u*	rm u[16] u*	u*	r u*	R̸ u*	R̸ u*	u,s	r[17]		s,U
12 Glycine	R̸ u*	rm u*	u*	r u*	R̸ u*	R̸ u*	r[18] u	r		r[22] U
13 Histidine	R̸ u*	r rm u*	r u*	r rm u*	R̸ u*	r u*	r[18] s u	r[17]		R[23]
14 Isoleucine	R̸ u*	rm u*	rm u*	r rm u*	R̸ u*		r[18] u	r[17]		R[23]
15 Leucine	R̸ u*	rm u*	rm u*	r rm u*	R̸ ụ̸	R̸ u*	r[18] u	r[17] u		R[23]

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Including colorless phytoflagellates /4/ Most grow better on organic than on inorganic N /5/ Many require living prey /6/ On assumption that suitable amino acid combinations can replace complete proteins /7/ See strepogenin (table 6) /8/ Entire peptides polypeptides low molecular weight proteins directly assimilated by some /9/ Either 3 or 4 required by photoautotrophs growing in dark /10/ Several tested intact plants grow on single amino acids as sole N-source Growth attained on some amino acids is superior to that achieved with NH_4^+ NO_3 as N source on other amino acids inferior Some plants grow less well on amino acids than on inorganic N Marked differences exist between species with respect to amino acid utilization Some amino acids are toxic under the experimental conditions used for some plants Among plants tested are: tomato tobacco clover peas orchid embryos young orchid (For Footnotes 11-25 see following page)

PEPTIDES PROTEINS (Concluded)

Requirement depends on inability of an organism to synthesize needed molecular structure. Amino acids not known to be required from the environment by any organism, e g hydroxyproline iodogorgoic norleucine ornithine thyroxine are omitted. No distinction between dextro- and laevo-isomers is made although they are not in many cases nutritionally equivalent. It is noteworthy that in one concentration an amino-acid may support good growth in another concentration inhibit or be toxic. When requirement and utilization are noted together it is to be understood that at least one member of group requires the amino-acid specifically, other members do not require but utilize it as a general nitrogen source for energy or synthesis of other compounds. Only needs of intact organisms are considered.

R Required by all forms studied; R̸ Not required by any form studied; r Required by one or more species or strains; rm Required by one or more mutants; U Utilized as source of nitrogen and/or carbon by all forms studied although not a specific requirement for all; u Utilized by one or more species or strains as a source of nitrogen and/or carbon although not a specific requirement; u* Replaces effectively one or more other amino acids, one of the interchangeable series being required in the diet; u̸ Not utilized by one or more species or strains; s Stimulates growth or other processes for one or more species or strains; Serves as complete nitrogen source for one or more species or strains; Serves as simplest complete nitrogen source for one or more species or strains

Nutrient / Groups of Organisms	Plants: Higher Green Plants[1]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Plants: Green Phyto-flagellates[2]	Animals: Protozoa[3]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
16 Lysine	R̸ u*	rm u*	u*	r rm u*	R̸ u̸	R̸ u*	r[18] u	r[17]		R[23]
17 Methionine	R̸ u*	r rm u*	u*	rm u*	R̸ u̸	r	r[18] u	r[17]		R[23] 24
18 Phenylalanine	R̸ u*	rm u*	rm, u*	r rm u*	R̸ u̸	R̸ u*	r[18] u	r[17] u*		R[23] 24
19 Proline	R̸ u*	rm u*	u*	r u*	R̸ u̸	R̸ u*	r[18] u	r[17]		R̸ U
20 Serine	R̸ u*	rm, u*	u*	r u*	R̸ u̸	R̸ u*	r[18] u	r[17]		R̸ U
21 Threonine	R̸ u*	rm, u*	u*	r u*	R̸ u̸		r[18] u	r[17] u*		R[23]
22 Tryptophan[25]	R̸ u*	rm, u*	u*	r rm u*	R̸ u*	R̸ u̸	r[18] u	r[17] s u*		R[23]
23 Tyrosine	R̸ u*	rm u*	u*	r rm, u*		R̸ u̸	r[18]	u		R̸, U
24 Valine	R̸ u*	rm u*	u*	r rm u*	R̸ u*	R̸ u*	r[18] s u	r[17] u		R[23]

/11/ Amino acid mixtures superior to NH_4 as N-source for some, e g Saccharomyces cerevisiae, S carlsbergensis. /12/ Wide differences of requirement exist between species, species mutants, e g Leuconostoc mesenteroides R all the amino acids listed except 5 and 8, Lactobacillus bifidus R only 9. /13/ Based mainly on Chlorella pyrenoidosa. /14/ Marked differences between various species and varieties with respect to amino acid utilization; environmental conditions sharply modify. /15/ Best known requirements are those of Tetrahymena, Trichomonas foetus, Herpetomonas culicidarum, Glaucoma scintillans. /16/ Interchangeable for Neurospora mutant. /17/ Basic common requirements of Tribolium confusum, Drosophila melanogaster, Aedes aegypti, Blattella germanica are covered by 6 10 13 18 21 22 24. For A. aegypti 18 or 21 + 22 + 24 may be eliminated from diet. For B germanica 5 7 11 but one at least must be present; mal also R 19 20; 9 10 17 and may be replaced by homocysteine cysteic acid isethionic acid inorganic SO_4; 15 24 u ; 18-23 and may be replaced by 3 4-dihydroxyphenylalanine phenylacetic 2 4-dihydroxybenzoic shikimic orsellinic acids. /18/ R by Tetrahymena geleii, Glaucoma scintillans, Trichomonas foetus. Herpetomonas culicidarum are 6 13 18, 22 24; in addition G scintillans T foetus R 12 19-21 and H culicidarum R 23. T geleii needs no other carbon source. /19/ R by rat, old hen. /20/ Asparagine (amide of 7) and glutamine (amide of 11) U by at least some in all the groups listed and R by some. /21/ 6 8 interchangeable for some. /22/ R by chick for rapid growth. /23/ R by man, mouse, rat, chicken; 13 not required to maintain nitrogen balance in adult human. /24/ Amount of methionine R by man depends on amount of cystine in diet. Amount of phenylalanine R by man depends on amount of tyrosine in diet. /25/ Precursor of niacin which it spares for some organisms.

3 NUTRIENTS ESSENTIAL ORGANIC COMPOUNDS: LIPIDS

Compounds listed as R or r are required for some detail of molecular structure that the organism cannot adequately synthesize

R̸ Not required by any form studied; r Required by one or more species or strains; rm Required by one or more mutants; u Utilized by one or more specie or strains; u= Utilized as effectively as a related substance by one or more species or strains; s Stimulates growth or other processes for one or more species or strains; i Inhibits growth or other processes for one or more species or strains

	Nutrient Compound / Groups of Organisms	Plants: Higher Green Plants[1]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Plants: Green Phytoflagellates[2]	Animals: Protozoa[3]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Steroids										
1	Cholesterol	R̸	r[4]	u	u	R̸	R̸	r[5]	R		R̸
2	7-Dehydrocholesterol	R̸	R̸	R̸	R̸	R̸	R̸	R̸ u[6]	u=		u[7]
3	Ergostanol acetate	R̸	R̸	R̸	R̸	R̸	R̸	R̸ u=[6]			s[8]
4	Ergosterol	R̸	R̸	u s	R̸	R̸	R̸	R, u=[6]	u=		u[9]
5	Stigmasterol	R̸	R̸	R̸	R̸	R̸	R̸	r[10]	u=		R̸
	Long Chain Fatty Acids and Their Derivatives										
6	Arachidonic acid[11]	R̸		R̸		R̸	R̸		s		r u
7	Linoleic acid[11]	R̸	rm	R̸	s i	R̸	R̸	u=[12]	r		r u=
8	Linolenic acid[11]	R̸		R̸		R̸	R̸		u		r u
9	Oleic acid	R̸	rm s	R̸	s i	R̸	R̸	s i	r		R̸
10	"Tween 80" 8g=[13]	R̸	R̸	R̸	R̸ s i	R̸	R̸	R̸ s	R̸		R̸
11	"Myrj G 2144"[13]	R̸	R̸	R̸	R̸	R̸	R̸	R̸ s	R̸		R̸
	Phospholipids										
12	Lecithin[14]	R̸	R̸	R̸	R̸	R̸	R̸	s	u s		R̸

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Including the colorless phytoflagellates /4/ r by Labyrinthula vitellina (var pacifica only) /5/ For several individual insect species various steroids u= /6/ u in place of 1 by Trichomonas /7/ Precursor of vitamin D_3 /8/ Relieves stiffness syndrome of guinea pig /9/ Precursor of vitamin D_2 /10/ R by Paramecium aurelia; a requirement of P aurelia for Sitosterol has also been noted /11/ The essential fatty acids of vertebrates /12/ u= a required ether soluble factor of blood serum by Trichomonas /13/ Synthetic detergents; 10 = sorbitan esters of fatty acids e g oleic; 11 polyoxyalkalene derivative of oleic acid. /14/ Ill-defined complex mixture of di-esters of α-glycerophosphoryl choline with many unsaturated fatty acids and other substances especially amino acids

2 NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS AMINO ACIDS PEPTIDES PROTEINS (Concluded)

Requirement depends on inability of an organism to synthesize a needed molecular structure. Amino acids not known to be required from the environment by any organism, e g hydroxyproline iodogorgoic norleucine ornithine thyroxine are omitted. No distinction between dextro and laevo isomers is made although they are not in many cases nutritionally equivalent. It is noteworthy that in one concentration an amino-acid may support good growth, in another concentration inhibit or be toxic. When requirement and utilization are noted together it is to be understood that at least one member of a group requires the amino-acid specifically, other members do not require but utilize it as a general nitrogen source for energy or synthesis of other compounds. Only needs of intact organisms are considered.

R Required by all forms studied; R̸ Not required by any form studied; r Required by one or more species or strains; rm Required by one or more mutants; U Utilized as a source of nitrogen and/or carbon by all forms studied although not a specific requirement for all; u Utilized by one or more species or strains as source of nitrogen and/or carbon although not a specific requirement; u= Replaces effectively one or more other amino acids, one of the interchangeable series being required in the diet; u̸ Not utilized by one or more species or strains; s Stimulates growth or other processes for one or more species or strains; * Serves as complete nitrogen source for one or more species or strains; ** Serves as simplest complete nitrogen source for one or more species or strains

Groups of Organisms / Nutrient	Plants						Animals			
	Higher Green Plants[1]	Fungi	Yeast	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Invertebrate: Insects	Invertebrate: Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
16 Lysine	R̸ u*	rm,u*	u*	r rm u*	R̸ u̸	R̸ u*	r[18] u	r[17]		R[23]
17 Methionine	R̸ u*	r rm u*	r u*	rm u*	R̸ u̸		r[18] u	r[17]		R[23] [24]
18 Phenylalanine	R̸ u*	rm u*	rm u*	r rm u*	R̸ u̸	R̸ u*	r[18] u	r[17] u=		R[23] [24]
19 Proline	R̸ u*	rm,u*	u*	r u*	R̸ u̸	R̸ u*	r[18] u	r[17]		R̸ U
20 Serine	R̸ u*	rm u*	u*	r u*	R̸ u̸	R̸ u*	r[18] s u	r[17]		R̸ U
21 Threonine	R̸ u*	rm u*	u*	r u*	R̸ u̸		r[18] u	r[17] u=		R[23]
22 Tryptophan[25]	R̸ u*	r rm u*	u*	r rm,u*	R̸ u*	R̸ u̸	r[18] u	r[17] u=		R[23]
23 Tyrosine	R̸ u*	rm,u*	u*	rm,u*		R̸ u̸	r[18] u	u		R̸,U
24 Valine	R̸ u*	rm u*	u*	r rm u*	R̸ u*	R̸ u*	r[18] s u	r[17] u		R[23]

/11/ Amino acid mixtures superior to NH_4 as N-source for some, e g Saccharomyces cerevisiae, S carlsbergensis. /12/ Wide differences of requirement exist between species, specie mutants, e g Leuconostoc mesenteroides R all the amino acids listed except 5 and 8; Lactobacillus bifidus R only 9. /13/ Based mainly on Chlorella pyrenoidosa. /14/ Marked differences between various species and varieties with respect to amino acid utilization; environmental conditions sharply modify. /15/ Best known requirements are those of Tetrahymena, Trichomonas foetus, Herpetomonas culicidarum, Glaucoma scintillans. /16/ Interchangeable for Neurospora mutant. /17/ Basic common requirements of Tribolium confusum, Drosophila melanogaster, Aedes aegypti, Blattella germanica are covered by 6 10 13 18 21 22 24. For A. aegypti 18 or 21, 22 + 24 may be eliminated from diet. For B. germanica 5 7 11 but one at least must be present; male also R 19 20; 9 10 17 and may be replaced by 3 4-dihydroxyphenylalanine phenylacetic 2 4-dihydroxybenzoic shikimic orsellinic acids. SO_4; 15 24 ; 18-23 and may be replaced by homocysteine cysteic acid isethionic acid inorganic /18/ R by Tetrahymena geleii, Glaucoma scintillans, Trichomonas foetus, Herpetomonas culicidarum are 6 13 18 22 24; in addition G scintillans R, T foetus R 12, 19-21 and H culicidarum R 23. T geleii needs no other carbon source. /19/ R by rat, chicken. /20/ Asparagine (amide of 7) and glutamine (amide of 11) U by at least some in all the groups listed and R by some. /21/ 6 8 interchangeable for some. /22/ R by chick for rapid growth. /23/ R by man, mouse, rat, chicken; 13 not required to maintain nitrogen balance in adult human. /24/ Amount of methionine R by man depends on amount of cystine in diet. Amount of phenylalanine R by man depends on amount of tyrosine in diet. /25/ Precursor of niacin which it spares for some organisms.

2 NUTRIENTS ESSENTIAL ORGANIC COMPOUNDS: AMINO ACIDS, PEPTIDES PROTEINS (Concluded)

Requirement depends on inability of an organism to synthesize needed molecular structure Amino acids not known to be required from the environment by any organism e g hydroxyproline iodogorgoic norleucine ornithine thyroxine are omitted No distinction between dextro- and laevo isomers i made although they are not in many cases nutritionally equivalent It i noteworthy that in one concentration an amino-acid may support good growth in another concentration inhibit or be toxi When requirement and utilization are noted together it i to be understood that at least one member of a group requires the amino-acid specifically other members do not require but utilize it as general nitrogen source for energy or synthesis of other compounds Only needs of intact organisms are considered

R Required by all forms studied; R̸ Not required by any form studied; r Required by one or more species or strains; rm Required by one or more mutants; U Utilized as a source of nitrogen and/or carbon by all forms studied although not a specific requirement for all; u Utilized by one or more species or strains as a source f nitrogen and/or carbon although not a specific requirement; u- -Replaces effectively one or more other amino-acids one of the interchangeable series being required in the diet; u̸ Not utilized by one or more species or strains; s Stimulates growth or other processes for one or more species or strains; Serves as complete nitrogen source for one or more speci or strains; **-Serves as simplest complete nitrogen source for one or more species or strains

	Groups of Organisms	Plants						Animals			
									Invertebrate		
	Nutrient	Higher Green Plants[1]	Fungi	Yeasts	Bacteri	Algae	Green Phyto flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
16	Lysine	R̸ u*	rm u*	u*	rm u*	R̸ u̸	R̸ u*	r18 u	r17		R25
17	Methionine	R̸ u*	r rm u*	u*	r rm u*	R̸ u̸		r18 u	r17		R25 24
18	Phenylalanine	R̸ u*	rm u*	rm u*	rm u*	R̸ u̸	R̸ u*	r18 u	r17 u-		R25 24
19	Proline	R̸ u*	rm u*	u*	u*	R̸ u̸	R̸ u*	r18 u	r17		R̸ U
20	Serine	R̸ u*	rm u*	u*	r u*	R̸ u̸	R̸ u*	r18 u	r17		R̸ U
21	Threonine	R̸ u*	rm, u*	u*	u*	R̸ u̸		r18 u	r17 u-		R25
22	Tryptophan[25]	R̸ u*	rm, u*	u*	rm, u*	R̸ u*	R̸ u̸	r18 u	r17 u-		R25
23	Tyrosine	R̸ u*	rm u*	u*	rm u*		R̸ u̸	r18 u	u		R̸, U
24	Valine	R̸ u*	rm u*	u*	r rm u*	R̸ u*	R̸ u*	r18 u	r17 u		R25

/11/ Amino acid mixtures superior to NH_4 as N-sourc for some e g Saccharomyces cerevisiae S carlsbergensi /12/ Wide differences of requirement exist between species species mutants g Leuconostoc mesenteroids R all the amino acids listed except 5 and 8 Lactobacillus bifidus R only 9 /13/ Based mainly on Chlorella pyrenoidosa /14/ Marked differences between various speci s and varieti with respect to amino acid utilization; environmental conditions sharply modify /15/ Best known requirements are those of Tetrahymena Trichomonas foetus Herpetomonas culicidarum Glaucoma scintillans /16/ Interchangeable for a Neurospora mutant /17/ Basi common requirements of Tribolium confusum Drosophila melanogaster Aedes aegypti Blattella germanica are covered by 6 10 13 18 21 22 24 For A. aegypti 18 or 21 22 + 24 may be eliminated from diet For B germanica 5 7 11 but one at least must be present; male also R 19 20; 9 10 17 and may be replaced by homocysteine cysteic acid isethionic acid inorganic SO_4; 15 24 u ; 18-23 and may be replaced by 3 4-dihydroxyphenylalanine phenylacetic 2 4-dihydroxybenzoi shikimic orsellinic acids /18/ R by Tetrahymena geleii Glaucoma scintillans Trichomonas foetus Herpetomonas culicidarum are 6 13 18 22 24;in addition G scintillans T foetus R 12 19-21 and H culicidarum R 23 T geleii needs no other carbon source /19/ R by rat, chicken /20/ Asparagine (amide of 7) and glutamine (amide of 11) U by t least some in all the groups listed and R by some /21/ 6 8 interchangeable for some /22/ R by chick for rapid growth /23/ R by man, mouse rat chicken 13 not required to maintain nitrogen balance in adult human. /24/ Amount of methionine R by man depends on amount of cystine in diet Amount of phenylalanine R by man depends on amount of tyrosine in diet /25/ Precursor of niacin which it spares for some organisms

3 NUTRIENTS ESSENTIAL ORGANIC COMPOUNDS LIPIDS

Compounds listed as R or r are required for some detail of molecular structure that the organism cannot adequately synthesize

✗ Not required by any form tudied; r Required by one or more species or strains; rm = Required by one or more mutants; u = Utilized by one or more species or strains; u= Utilized as effectively as a related substance by one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains

	Nutrient Compound	Higher Green Plants[1] (Plants)	Fungi (Plants)	Yeasts (Plants)	Bacteria (Plants)	Algae (Plants)	Green Phytoflagellates[2] (Plants)	Protozoa[3] (Animals)	Insects (Animals, Invertebrates)	Other (Animals, Invertebrates)	Vertebrates (Animals)
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Steroids										
1	Cholesterol	✗	r[4]	u	u	✗	✗	r[5]	R		✗
2	7-Dehydrocholesterol	✗	✗	✗	✗	✗	✗	✗ u=[6]	u=		u[7]
3	Ergostenol acetate	✗	✗	✗	✗	✗	✗	✗ u=[6]			s[8]
4	Ergosterol	✗	✗	u s	✗	✗	✗	R, u=[6]	u=		u[9]
5	Stigmasterol	✗	✗	✗	✗	✗	✗	r[10]	u=		✗ s
	Long Chain Fatty Acids and Their Derivatives										
6	Arachidonic acid[11]	✗		✗		✗	✗	u=1	s		r u
7	Linoleic acid[11]	✗	rm	✗	s i	✗	✗		r		r u=
8	Linolenic acid[11]	✗		✗		✗	✗	s i	u		r u=
9	Oleic acid	✗	rm s	✗	s i	✗	✗	✗ s	r		✗
10	"Tween 80 85 13	✗	✗	✗	✗ s i	✗	✗		✗		✗
11	"Myrj 0 2144 13	✗	✗	✗	✗	✗	✗	✗ s	✗		✗
	Phospholipids										
12	Lecithin[14]	✗	✗	✗	✗	✗	✗	s	u= s		✗

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Including the colorless phytoflagellates /4/ r by Labyrinthula vitellina (var pacifica only) /5/ For several individual insect species various steroids u= /6/ u= in place of 1 by Trichomonas /7/ Precursor of vitamin D_3 /8/ Relieves stiffness syndrome of guinea pig /9/ Precursor of vitamin D_2 /10/ R by Paramecium aurelia; a requirement of P aurelia for Sitosterol has also been noted /11/ The essential fatty acids of vertebrates /12/ u= a required ether soluble factor of blood serum by Trichomonas /13/ Synthetic detergents; 10 sorbitan esters of fatty acids e g oleic; 11 polyoxalkalene derivative of oleic acid /14/ Ill-defined complex mixture of di-esters of α-glycerophosphoryl choline with many unsaturated fatty acids and other substances especially amino acids

4. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: VITAMINS AND RELATED COMPOUNDS

It is probable that many of these compounds participate indispensably in the metabolic activities of all living substance and are in this sense universally required. This tabulation, however, is limited to consideration of presently known requirement or non-requirement from the external environment or in the diet. Included in consideration are those instances in which metabolically essential compounds are provided to an organism by associated microorganisms which synthesize them, e.g., by the intestinal flora of mammals. The special needs of excised tissues or cells living apart from the intact organism are not considered. Environmental conditions may strongly modify the need for and/or the utilization of vitamins and growth factors. The characterization, "not required" (R̸) derives either from experimental proof gathered from the forms studied or from the current absence of data indicating requirement by the forms studied.

R Required by all forms studied; R̸ Not required by any form studied; r Required by one or more species or strains (OMSS); rm Required by one or more mutants; u Utilized by (OMSS); u= Utilized as effectively as the related compound( ) or vitamin by OMSS; u> Utilized more effectively than the related compound( ) or vitamin and considered to be required by OMSS; u< Utilized less effectively than the related vitamin by OMSS; =< Utilized as well or less effectively than the related vitamin by (OMSS); ũ Not utilized in place of the related vitamin by OMSS; s Stimulates growth or other processes for OMSS; i Inhibits growth or other processes for OMSS

	Compound	Related Compounds[1]	Higher Green Plants[2]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[3]	Protozoa[4]	Insects	Other	Vertebrates
			Plants						Animal: Protozoa	Invertebrates		
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
	Vitamins[5]											
1	Vitamin A	(ins)A_1,A_2,A_3,(rel) 21A	R̸	R̸	R̸	R̸	R̸	R̸	r?	R̸		R
2	Ascorbic acid		R̸,s	R̸	R̸	R̸,s	r?	R̸	r	R̸		
3	Biotin	(rel)20A,24A,30A 34A	R̸	rm				R̸				
4	Choline group[6]		R̸	,rm	R̸		R̸	R̸	R̸'			
5	Cobalamin[7]	(rel)39A,45A	R̸,s	R̸	R̸	r[8]		r		?		
6	Vitamin D[9]	(ins)D_2,D_3 D_4 etc	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸		R[9]
7	Vitamin E	(ins)α,β γ δ-Tocopherols	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸		
8	Inositol[10]	meso-Inositol	R̸	rm		r?	R̸	R̸	R̸	r		r?
9	Vitamin K	K_1,K_2	R̸	R̸	R̸		R̸	R̸	R̸			r
10	Nicotinic acid	(rel)11A,25A,46A	R̸ ?	,rm,			R̸	R̸				r
11	Nicotinamide	(rel)10A	R̸, ?	,rm,	u=	u=	R̸	R̸		u=		u=
12	Pantothenic acid	(rel)19A,22A,31A,35A	R̸,s	rm	r			R̸	r			R
13	Pteroylglutamic acid[11]	(rel)27A,40A,44A,49A	R̸	R̸	R̸	r[12]	R̸	R̸				R
14	Pyridoxal[13]	(rel)15A,16A,41A,42A	R̸	u-	u=	u>	R̸	R̸	u-	u=		
15	Pyridoxamine[13]	(rel)14A 16A,41A,42A	R̸	u=	u=	r u>	R̸	R̸	u=	u=		
16	Pyridoxine[13]	(rel)14A,15A 41A,42A	R̸	,rm,			R̸	R̸				R
17	Riboflavine		R̸	rm	R̸		R̸	R̸				R
18	Thiamine	(rel)26A,32A;(co)43A+47A	R̸,s	rm i[14]	r i[15]				r	r		R
	Compounds Chemically Related to Vitamins[5]											
19	β-Alanine	(po)12A	R̸	rm,u=	R̸ u=	R̸ u=	R̸	R̸	R̸ R̸	R̸		R̸
20	Biocytin	(rel)3A	R̸	R̸	R̸		R̸	R̸	R̸	R̸		R̸
21	β-Carotene[16]	(pre)1A	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸	r?[17]	R̸ u<
22	Coenzyme A	(co)12A+ADP+PO_4	R̸	R̸	R̸	u>	R̸	R̸	R̸	R̸		R̸ u<
23	5,6-Dimethylbenzimidazole	(po)9A	R̸	R̸	R̸	R̸	R̸	R̸ <	R̸	R̸		R̸ u<
24	Desthiobiotin	(rel)3A,30A 34A	R̸	R̸	R̸	R̸ u<	R̸	R̸	R̸	R̸		R̸
25	DPN[18]	(co)10A+ribose PO_4	R̸	r,u>	R̸,u=	r,u=	R̸	R̸	R̸	R̸,u=<		R̸,u=<

/1/ (co) composed of; (po) part of; (pre) precursor of; (rel) related to; (ins) Includes /2/ Spermatophytes (the intact plant) /3/ Green phytoflagellates, chrysomonads dinoflagellates /4/ Including the colorless phytoflagellates /5/ Vitamin an organic compound, other than an amino-acid carbohydrate or essential fatty acid, required in the diet by at least one vertebrate animal /6/ Includes choline betaine and other methyl donors & mono- and tri-ethyl choline ethanolamine diethylethanolamine mono- and di-ethylamino ethanol &c and tri-ethyl-choline /7/ Generic term including cyanocobalamin hydroxocobalamin vitamins B_{12}, B_{12a}, B_{12b} /8/ For some thymine desoxyriboside hypoxanthine adenine guanine may substitute in certain media /9/ D_2 active for mammals only; D_3 active for all and R by chicken. /10/ Of doubtful status as a vitamin /11/ Folic acid folacin. /12/ For one or more pteroic acid (q 40A) or thymine thymidine will substitute /13/ Member of the pyridoxine group (Vitamin B_6) /14/ Inhibits growth of Rhizopus nigricans /15/ Inhibits growth of strains of Saccharomyces cerevisiae /16/ And other carotenoid precursors of vitamin A. /17/ R? by certain crustacea whose eyes contain vitamin A. /18/ Diphosphopyridine nucleotide

4 NUTRIENTS ESSENTIAL ORGANIC COMPOUNDS: VITAMINS AND RELATED COMPOUNDS (Concluded)

It is probable that many of these compounds participate indispensably in the metabolic activities of all living substance and are, in this sense, universally "required." This tabulation, however, is limited to a consideration of presently known requirement or non-requirement from the external environment or in the diet. Excluded is consideration of those instances in which metabolically essential compounds are provided to an organism by associated microorganisms which synthesize them, e.g., by the intestinal flora of mammals. The special needs of cultured tissues or cells living apart from the intact organism, are not considered. Environmental conditions may strongly modify the need for and/or the utilization of vitamins and growth factors. The characterization "not required" (R̸) derives either from experimental proof gathered from the forms studied or from the current absence of data indicating requirement by the forms studied.

R = Required by all forms studied; R̸ = Not required by any form studied; r = Required by one or more species or strains (OMSS); rm = Required by one or more mutants; u = Utilized by OMSS; u= = Utilized as effectively as the related compound(s) or vitamin by OMSS; u> = Utilized more effectively than the related compound(s) or vitamin and considered to be required by OMSS; u< = Utilized less effectively than the related vitamin by OMSS; u=< = Utilized as well or less effectively than the related vitamin by OMSS; ú = Not utilized in place of the related vitamin by OMSS; s = Stimulates growth or other processes for OMSS; I = Inhibits growth or other processes for OMSS.

	Compound	Related Compounds[1]	Plants: Higher Green Plants[2]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Plants: Green Phytoflagellates[3]	Animals: Protozoa[4]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
	Compounds Chemically Related to Vitamins[5] Concluded											
26	Diphosphothiamine	(co)18A+PO4	R̸	R̸ u<	R̸ u=	u>	R̸	R̸ u=	R̸ u=	R̸		R̸ u=
27	Folic acid conjugates[19]	(co)13A+glutamate	R̸	R̸	R̸	R̸ u=	R̸	R̸	R̸ u=	R̸,u=		R̸ u=
28	Folinic acid[20]	(rel)13A	R̸	R̸	R̸	r	R̸	R̸	R̸,u=	R̸		R̸ u=
29	Hesperidin[21]	(pc) "Vitamin P" series	R̸,[illegible]	R̸	R̸	R̸	R̸	R̸	R̸	R̸		R̸
30	O-Heterobiotin	(rel)3A,...	R̸	R̸	R̸	R̸ u<,[illegible]	R̸	R̸	R̸	R̸		R̸
31	L.B. factor[22]	(rel)12A	R̸	R̸	R̸	r,u>	R̸	R̸	R̸	R̸		R̸
32	Lipothiamide	(co)18A+lipoic acid	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸		R̸,u=
33	Lyxoflavin	(rel)17A	R̸	R̸	R̸	R̸ u<	R̸	R̸	R̸	R̸		R̸ s,u<
34	Oxybiotin	(rel)3A,...	R̸	R̸	R̸	R̸ u<	R̸	R̸	R̸	R̸		R̸
35	"Pantothenic acid conjugate"	(co)10A+adenine+glutamate	R̸	R̸	R̸	rI u>	R̸	R̸	R̸	R̸		R̸
36	Pantoic acid	(pc)10A	R̸	R̸	R̸ u	R̸ u	R̸	R̸	R̸	R̸		R̸ ú
37	Para-aminobenzoic acid	(pc)13A	R̸	R̸,rm	r	r	R̸	R̸	r	R̸		R̸,ú
38	Pimelic acid	(rel, pc)3A	R̸	R̸,s	R̸	R̸,u<	R̸	R̸	R̸,u<	R̸		R̸ R̸
39	Pseudovitamin B12	(rel)5A	R̸	R̸	R̸	R̸,u=	R̸	R̸ u=	R̸	R̸		R̸ R̸
40	Pteroic acid	(pc)13A	R̸	R̸	R̸	R̸ u<	R̸	R̸	R̸ u=,ú	R̸		R̸,R̸
41	Pyridoxal-PO4	(rel)14A	R̸	R̸ u=	R̸ u	r u>	R̸	R̸	R̸ u=	R̸ u=		R̸ u=
42	Pyridoxamine-PO4	(rel)15A	R̸	R̸ u=	R̸ u	r u>	R̸	R̸	R̸ u=	R̸ u=		R̸ u=
43	Pyrimidine[23,24]	(pc)18A	R̸	r,rm,s[23,24]	r s[23,24]	r,s[23,24]	s[23,24]	r,s[23,24]	r s[23,24]	R̸		R̸,R̸
44	Rhizopterin	(rel pc)13A	R̸	R̸	R̸	R̸,u=	R̸	R̸	R̸	R̸		R̸,R̸
45	α-Ribazole	(pc)5A	R̸	R̸	R̸	R̸	R̸	R̸,u<	R̸	R̸		R̸ s
46	Rutin[21]	(pc) "Vitamin P" series	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸		R̸ s
47	Thiazole[24,25]	(pc)18A	R̸	r rm,s[24,25]	r s[24,25]	r s[24,25]	r s[24,25]	r s[24,25]	r s[24,25]	R̸		R̸
48	TPN	(co)10A+ribose+PO4	R̸	r u> s	R̸ u=	R̸ u=	R̸	R̸	R̸	R̸		R̸ u=
49	Xanthopterin	(rel pc)13A	R̸	R̸	R̸	R̸,u<	R̸	R̸	R̸	R̸		rI[26] u>[26] s

/1/ (co) = composed of; (pc) = part of; (pre) = precursor of; (rel) = related to; (inc) = includes. /2/ Spermatophytes (the intact plant). /3/ Green phytoflagellates, chrysomonads, dinoflagellates. /4/ Including the colorless phytoflagellates. /5/ Vitamin = an organic compound, other than an amino-acid, carbohydrate or essential fatty acid, required in the diet by at least one vertebrate animal. /19/ Di-, tri- and hepta-glutamates of pteroylglutamic acid. /20/ = The citrovorum factor, 5 by Leuconostoc citrovorum. /21/ [illegible] and citrin "Vitamin P" series. /22/ Lactobacillus bulgaricus factor which = pantetheine = pantothine (N-(pantothenyl) β-aminoethanol and corresponding di-sulfide). /23/ Thiamine or pyrimidine moiety (thiazole moiety is synthesized). /24/ Thiamine or pyrimidine + thiazole moieties (pyrimidine and thiazole moieties combined to give thiamine). /25/ Thiamine or thiazole moiety (pyrimidine moiety is synthesized). /26/ More active than pteroylglutamic (folic) acid in relieving anemia of Chinook salmon (fish).

...ENTS: ESSENTIAL ORGANIC COMPOUNDS PURINES, PYRIMIDINES

Purine and pyrimidine compounds are essential components of the nucleic acids. Inability to synthesize these compounds makes it necessary for many organisms to obtain them from an environmental or dietary source for nucleic acid synthesis and synthesis of other essential purine and pyrimidine compounds. For some organisms the requirement is for a specific compound(s), for others any one of an interchangeable series satisfies the need. The pyrimidines: cytosine thymine uracil and the purines: adenine and guanine combine with ribose or desoxyribose to form nucleosides (cytidine thymidine uridine adenosine, guanosine) which with H_3PO_4 form nucleotides: cytidylic uridylic adenylic and guanylic acids. Nucleotides combine to form polynucleotides. The nucleic acids are specific tetranucleotides. The characterization not required derives either from direct experimental evidence or absence of data presently indicating requirement.

N̸ = Not required by any form studied; r = Required by one or more species or strains; rm = Required by one or more mutants; u = Utilized by one or more species or strains; N̸ = Not utilized by one or more species or strains; u= = Utilized as effectively as (or interchangeably with) one or more related compounds the presence of at least one of the series being required by one or more species or strains; u< = Partially replaces or spares one or more required or interchangeably required compounds for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains

	Compound (A)	Higher Green Plants[1] (B)	Fungi (C)	Yeasts (D)	Bacteria (E)	Algae (F)	Green Phytoflagellates[2] (G)	Protozoa[3] (H)	Insects (I)	Other Invertebrates (J)	Vertebrates (K)
1	Pyrimidine compounds	N̸	r rm s	r s	r s u[4]	r	r	r 5,s	r		N̸,s
2	Purine compounds	N̸	rm,s,u[4]	s,u[4]	r,s,u[4]	N̸	N̸	r,5,s	r		N̸ s
	Compounds Containing Pyrimidine Ring[6]										
	Cytidine	N̸	N̸ rm s	N̸	u=7	N̸	N̸	u= i	N̸		N̸
	Cytidylic acid	N̸	N̸ rm s[8]	N̸	u=7	N̸	N̸	u s	N̸		N̸
5	Cytosine	N̸	rm	N̸	u=9	N̸	N̸	r? N̸ 10,i	N̸		N̸
	Orotic acid	N̸	rm s[8]	N̸	r[11] s	N̸	N̸	N̸ N̸[10]	N̸		N̸ s
	Pyrimidine[12]	See Table 4	See Table 4								
	Thymine	N̸	N̸	N̸	u=15 u<14	N̸	N̸ u<15	r?,u<16	r		N̸ s
	Thymidine	N̸	N̸	N̸	u<14	N̸	N̸	u<16	N̸		N̸ s
	Uracil	N̸	rm s[8]	N̸	u=7 s	N̸	r?	r u=17	r[18]		N̸
	Uridine	N̸	N̸ rm s	N̸	u=7,s	N̸	N̸	u=	N̸		N̸
	Uridylic acid	N̸	N̸ rm s[8]	N̸	u=7,s	N̸	N̸	u=	N̸		N̸

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Including colorless phytoflagellates /4/ Numerous pyrimidine and purine compounds utilized as nitrogen sources by fungi yeasts and bacteria which do not ...compounds specifically /5/ Requirements of Tetrahymena geleii have been most extensively studied /6/ A 6 atom ring ... the latter in the 1 and 3 positions /7/ At least one required but interchangeable for several species of Leuconostoc ... Hemophilus parainfluenzae /8/ Stimulates mutants of Neurospora /9/ Lactobacillus arabinosus ... or 17 (interchangeable) /10/ N̸ by Tetrahymena /11/ r by Lactobacillus bulgaricus 09 /12/ Pyrimidine moiety of ... Clostridium tetani r either 13 or 20 (interchangeable) /14/ Spares folic acid for Streptococcus lactis; 8 + 9 re... ac d for S lactis /15/ Spares and given with amino-acids substitutes for para-aminobenzoic and folic acids for Euglena ...acilis /16/ Spares fo... acid for Tetrahymena /17/ For Tetrahymena 10 or 3 & 11 or 12 r /18/ Drosophila melanogaster r 10 + sucrose ... nucleic acid.

NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: PURINES PYRIMIDINES (Concluded)

Purine and pyrimidine compounds are essential components of the nucleic acids Inability to synthesize these compounds makes it necessary for many organisms to obtain them from an environmental or dietary source for nucleic acid synthesis and synthesis of other essential purine and pyrimidine compounds For some organisms the requirement is for a specific compound(s) for others any one of an interchangeable series satisfies the need. The pyrimidines: cytosine thymine uracil and the purines: adenine and guanine combine with ribose or desoxyribose to form nucleosides (cytidine thymidine uridine adenosine guanosine) which with H_3PO_4 form nucleotides: cytidylic uridylic adenylic and guanylic acids Nucleotides combine to form polynucleotides The nu cleic acids are specific tetranucleotides The characterization not required derives either from direct experimental evidence or absence of data presently indicating requirement

X Not required by any form studied; r = Required by one or more species or strains; rm = Required by one or more mutants; u = Utilized by one or more species or strains; X = Not utilized by one or more species or strains; "u= = Utilized as effectively as (or interchangeably with) one or more related compounds the presence of at least one of the series being required by one or more species or strains u< = Partially replaces or spares one or more required or interchangeably required compounds for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other pro- cesses for one or more species or strains

	Compound (A)	Plants: Higher Green Plants[1] (B)	Plants: Fungi (C)	Plants: Yeasts (D)	Plants: Bacteria (E)	Plants: Algae (F)	Plants: Green Phyto flagellates[2] (G)	Animals: Protozoa[3] (H)	Animals: Invertebrates: Insects (I)	Animals: Invertebrates: Other (J)	Animals: Vertebrates (K)
	Compounds Containing Purine Ring[19]										
13	Adenine	X	rm	r[20]	u=21	X	X u<15	r? u<22	r[18]		X s
14	Adenosine	X	X	X	u=21	X	X	X u<22	X		X
15	Adenosine triphosphate	X	X	X	u=21	X	X	X s	X		X
16	Adenylic acid	X	X	X	u=21	X	X	r, u<22	X		X
17	Guanine	X	r rm s	X	u=9 21 s	X	s	r<3	r[18]		X s
18	Guanosine	X	X	X	u=21	X	X	r? u= u<24 i	X		X
19	Guanylic acid	X	X	X	u=21	X	X	u s	X		X
20	Hypoxanthine	X	r rm	X	u=21 s	X	s	u= u<22	X		X
21	Xanthine	X	X	X	u=20	X	X	r, 23 X10	X		X
22	Others	X		X		X		s26			

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Including colorless phyto- flagellates /9/ Lactobacillus arabinosus Leuconostoc mesenteroides r 5 or 17 (interchangeable) /10/ X by Tetrahymena /15/ Spares and given with amino-acids substitutes for para-aminobenzoic and folic acids for Euglena gracilis /18/ Drosophila melanogaster r 10 + sucrose 10 + 13 + 17 or nucleic acid /19/ The purine ring structure = a pyrimidine ring and imidazole ring (3C 2N) with two carbons in common /20/ r by Saccharomyces octosporus on certain media /21/ Items 13 21 variously interchangeable for different bacteria but at least one must be present e g Streptococcus hemolyticus r at least one of 13 14 16 17 18 19 21 (the re quirement is relieved by CO_2 in high concentration) 13 17 20 or 21 r by Streptococcus lactis; 14 r by B megaterium for spore ger mination /22/ Spares but cannot replace 17 18 [illegible]

6 NUTRIENTS ESSENTIAL ORGANIC COMPOUNDS: MISCELLANEOUS GROWTH FACTORS

As the title suggests this table lists compounds that favorably affect or are essential for the growth process in some aspect but which have not found ready classification in tables 1 2 3 4 5 7 8 9 Many of these compounds in addition to the specific activity which they have for some organisms are utilized by others simply for their carbon, nitrogen and/or hydrogen content In this last respect CO_2 glutamine and asparagine are excellent examples The characterization not required derives either from direct experimental evidence or the absence of data indicating requirement by forms presently studied

R Required by all forms studied; Ɍ Not required by any forms studied; r Required by one or more species or strains; rm Required by one or more mutants; u_R Replaces effectively or utilized interchangeably with one or more other substances but one of the interchangeable substances must be present; s Stimulates growth or other processes for one or more species or strains; i Inhibits growth or other processes for one or more species or strains

	Nutrient Compound / Groups of Organisms	Plants						Animals			
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Invertebrates		Vertebrates
									Insects	Other	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Adenylthiomethylpentose[4]	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ s
2	Anthranilic acid[5]	Ɍ	r, rm[6]	Ɍ	u_R[6]	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ s
3	Antibiotics[7]	Ɍ	Ɍ	Ɍ	r[8]	Ɍ	Ɍ	Ɍ s	Ɍ		Ɍ s
4	Asparagine	Ɍ	Ɍ	Ɍ s i	r[9]	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
5	"Bifidus factor"[10]	Ɍ	Ɍ	Ɍ	r	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
6	Carbon dioxide	R	r[11] s i		r[11] s	R	R[12] s	r[13]	Ɍ		Ɍ
7	Carnitine[14]	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	r[15]		Ɍ
8	Coprogen[16]	Ɍ	r	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
9	N-D-Glucosylglycine ester	Ɍ	Ɍ	Ɍ	r	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
10	Glutamine	Ɍ	Ɍ s i	s i	r[9] s	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
11	Glutathione	Ɍ	Ɍ	Ɍ	r[17]	Ɍ	Ɍ	Ɍ	s[18]		Ɍ
12	Guanidine	Ɍ	Ɍ		Ɍ	Ɍ	Ɍ	ri[19]	Ɍ		Ɍ

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads, dinoflagellates /3/ Including colorless phytoflagellates /4/ "Vitamin L_2, a purine nucleoside /5/ "Vitamin L_1 precursor of nicotinic acid /6/ Substitutes for tryptophan and/or indol /7/ Aureomycin, penicil--, streptomycin, bacitracin neomycin and other substances s arsenicals and sulfonamides which may in small amounts /8/ R by dependent mutants growth factor and not replaceable by aspartic or glutamic acids /10/ α and β-Methyl-N-acetyl-d-glucosaminide? /11/ R by some in higher than --ic concentrations /12/ R although another carbon source is available, particularly in darkness Functions in metabolism of C_3 and C_4 com-- a Wood-Werkman reaction. /13/ R by some colorless phytoflagellates /14/ α-hydroxy-γ aminobutyric acid /15/ R by Tenebrio molitor; inter-- s with γ-amino-β-hydroxybutyric acid /16/ Fe containing molecule of unknown structure not heme compound /17/ R by Neisseria gonorrhoeae --rs larval growth of Drosophila and Aedes aegypti /19/ Possibly R by Plasmodium in vitro; Ɍ by Tetrahymena

6 NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: MISCELLANEOUS GROWTH FACTORS (Concluded)

As the title suggests, this table lists compounds that favorably affect, or are essential for, the growth process in some aspect but which have not found ready classification in table 1, 3, 4, 5, 7, 8, 9. Many of these compounds, in addition to the specific activity which they have for some organisms, are utilized by others simply for their carbon, nitrogen and/or hydrogen content. In this last respect CO_2, glutamine, and asparagine are excellent examples. The characterizations not required are either from direct experimental studies or the absence of data indicating requirement by forms presently studied.

R = Required by all forms studied; N = Not required by any form studied; r = Required by one or more species or strains; m = Required by one or more mutants; u = Replaces effectively or utilized interchangeably with one or more other substances, but one of the interchangeable substances must be present; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains.

Nutrient Compound	Plant: Higher Green Plant[1]	Plant: Fungi	Plant: Yeast	Plant: Bacteria	Plant: Algae	Plant: Green Phytoflagellates[2]	Animals: Protozoa[3]	Animals: Invertebrate: Insects	Animals: Invertebrate: Other	Animals: Vertebrate
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
81 [illegible]-acetic acid[5]	N s	rs	N	N s	N s	N s[1]	r[1] i	N		N si
82 [illegible]	N	r	N		N	N	r	r		N
83 Krebs cycle intermediates[3]	N	r	N	r	N	r[4] s	N i	N		N
84 Hemin	N	N	N	r[5]	N	N	N	N		N s
85 Mycobactin[7]	N	N	N	r[7]	N	N	N	N		N
86 Parahydroxybenzoic acid	N	rm	N	rm	N	N	N	N		N
87 Putrescine	N	rm	N	ru[8]	N	N	N	N		N
88 Shikimic acid[9]	N	rm	N	rm	N	N	N	N u[11]		N
89 Histidine peptides[10]	N	rm	N	rm	N	N	N	u[11]		
90 Spermidine[11]	N	N	N	ru[23]	N	N	N	N		N
91 Tyrosine peptides[12]	N	N st	N	r rm s	N	N	N	N		N
92 Thioctic acid[33]	N	N	N	r	N	N	N r[34]	N		N st
93 Unidentified factors[35]		r		r			r	r		N r

[1] Spermatophytes (the intact plant). [2] Green phytoflagellates, chrysomonads, dinoflagellates. [3] Including colorless phytoflagellates. [4] Also [illegible] effective for Astasia (colorless counterpart of Euglena). [5] Also hemin, protoheme, protoporphyrin and several porphyrins. [6] Several utilized for growth by the [illegible] and [illegible] compounds such as pyruvate. [7] Mycobacterium johnei. [8] Interchangeable with agmatine, spermine. [9] Probable precursors of aromatic amino-acids. [30] Spares or replaces phenylalanine, tyrosine for [illegible]. [31] [illegible]. [32] Also d-alanyl-histidine, amino-n-butyryl L-histidine, carnosine, various tyrosine peptides. [33] Exists in tissues as lipothiamide (q.v.), which catalyzes the oxidation of pyruvate and α-ketoglutarate. [34] R by Tetrahymena gelii (2 strains); spared but not replaced by acetate; R by Peranema trichophorum. [35] For example, tissue extracts, unknown substances present in living tissue or protoplasm.

Auxin-related substances (plant hormones), e.g. 3-indoleacetic, naphthalene acetic, phenylacetic acids, etc. Krebs cycle intermediates: 2-ketoglutarate, oxaloacetate, succinate, cis-aconitate, isocitrate, malate, oxalosuccinate, fumarate, citrate, acetate; utilized by most, wide variation among species with respect to utilization or availability of individual Krebs intermediates. Corynebacterium diphtheriae. $C_{47}H_{75}O_{17}N_5$.

7 NUTRIENTS GENERAL NITROGEN SOURCES

Nitrogen is a universal requirement of living organisms. Utilizable as molecular N_2 by some organisms, it is required by most in the form of its compounds. This tabulation lists the important classes of nitrogen compounds utilizable from an environmental or dietary source for general nitrogen metabolism. Certain nitrogen compounds which serve as adequate general nitrogen sources for some organisms are required as specific growth factors or essential nutrients by others, e.g. the purine, pyridine and pyrimidine compounds.

R Required by all forms studied; Ɍ = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U Utilized by all forms studied; Ʉ Not utilized by any forms studied; u = Utilized by one or more species or strains; ʉ Not utilized by one or more species or strains; Stimulates growth or other processes for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; + Serves as adequate or partial N-source for one or more species or strains; ++ = simplest adequate N-source for one or more species or strains

	Nitrogen Source / Groups of Organisms	Plants						Animals			
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[2]	Protozoa[3]	Invertebrates: Insects	Invertebrates: Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Nitrogen Source	R	R	R	R	R	R	R	R	R	R
	Inorganic Nitrogen Sources										
2	Nitrogen molecular N_2	u[4]	Ɍ u?[5]	Ɍ	u++[6]	Ɍ u++[7]	Ɍ	Ɍ	Ɍ		Ɍ
3	Ammonia ion NH_3, NH_4^+	Ɍ U++	rm,u++[8]	Ɍ u++	Ɍ u+[9]	Ɍ, U++[10]	Ɍ U++	r u++	Ɍ u?		Ɍ u[11]
4	Hyponitrite $-HN_2O_2$ or $-N_2O_2$	Ɍ Ʉ[12]	Ɍ ʉ[13]		Ɍ u[14]	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
5	Nitrite $-NO_2$	Ɍ u+[15]	rm u++[16]	Ɍ u+	Ɍ u+	Ɍ u+[17]	Ɍ	Ɍ	Ɍ		Ɍ
6	Nitrate $-NO_3$	Ɍ U+	rm u++[18]	Ɍ u+[19]	Ɍ u+[20]	Ɍ U+[21]	Ɍ u+[22]	Ɍ u	Ɍ		Ɍ
7	Nitrohydroxamate $-HN_2O_3$	Ɍ u+[23]	Ɍ u+[24]	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
8	Cyanide $-CN^-$	Ɍ	Ɍ u+[25]	Ɍ	Ɍ	Ɍ	Ɍ	Ɍ[26]	Ɍ[26]		Ɍ[26]
9	Thiocyanate $-CNS^-$	Ɍ	Ɍ u?	Ɍ u	Ɍ u+	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ
10	Cyanamide $HNCN^-$	Ɍ	u+[27]	Ɍ	Ɍ u+[27]	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates, chrysomonads, dinoflagellates /3/ Including the colorless phytoflagellates /4/ U by virtue of symbiotic bacteri as in root nodules of legumes /5/ Evidence for N_2 fixation conflicting. /6/ U by N_2 fixing bacteria. /7/ N_2 fixation" by blue-green algae Nostocaceae Ʉ if H_2 or CO present /8/ U by Phycomyces blakesleeanus, Mucorales. Probably U by all fungi. /9/ Many bacteria R specific amino acids from the environment but as a class U NH_4^+ for synthesis of other amino acids. /10/ U in preference to NO_3 by Chlorella. /11/ Dietary NH_4^+ U by ruminants; possibly others; NH_4^+ originating as metabolic intermediate U in amino acid synthesis /12/ Ʉ by tobacco plant /13/ Ʉ by Aspergillus niger /14/ U by Clostridium pasteurianum, but not for growth; Ʉ for denitrification by Pseudomonas stutzeri /15/ Toxic to many plants; poorly U by tobacco plant. /16/ U as sole N-source by many fungi /17/ U poorly by Chlorella pyrenoidosa. /18/ Acts as sole N acceptor in anaerobic metabolism of Aspergillus niger. R by some when mannitol is carbon source. Some R NO_3, cannot substitute NH_4^+ /19/ U poorly by most yeasts /20/ Ʉ by purple photosynthetic bacteria. /21/ U in light, Ʉ in dark by some /22/ U in light, Ʉ in dark by some; Ʉ either in light or dark by some /23/ Good N-source for tobacco plant /24/ Good N-source for Aspergillus niger /25/ U by Aspergillus niger when N-starved. /26/ Toxic. /27/ Cyanamide and derivatives U by many

7 NUTRIENTS GENERAL NITROGEN SOURCES (Concluded)

Nitrogen is universal requirement of living organisms Utilizabl as molecular N_2 by some organisms it is required by most in the form of its compounds This tabulation lists the important classes of nitrogen compounds utilizable from an environmental or dietary source for general nitrogen metabolism. Certain nitrogen compounds which serve as adequate general nitrogen sources for some organisms are required as specific growth factors or essential nutrients by others e g. the purine, pyridine and pyrimidine compounds

R Required by all forms studied; R̸ = Not required by any forms studied; r Required by one or more species or strains; rm = Required by one or more mutants; U Utilized by all forms studied; U̸ Not utilized by any forms studied; u = Utilized by one or more species or strains; u̸ = Not utilized by one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; + Serves as adequate or partial N-source; ++ = Simplest adequate N-source for one or more species or strains

	Nitrogen Source (Groups of Organisms)	Plants: Higher Green Plants[1]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Plants: Green Phytoflagellates[2]	Animals: Protozoa[3]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Organic Nitrogen Sources										
11	Oximino compounds[28] RCNOH	R̸ U[29]	R̸ u+	R̸ u+	R̸ u+[30]	R̸[31]	R̸	R̸	R̸		R̸
12	Amines[32] RNH_2	R̸	R̸,u+	R̸ u+	R̸ u+	R̸ u+[33]	R̸	R̸	R̸		R̸
13	Acid imides[34], $(RCO)_2NH$	R̸	R̸	R̸	R̸ u+	R̸	R̸	R̸	R̸		R̸
14	Acid amides[35] $RCONH_2$	R̸ u+[36]	R̸ u+[37]	r,u+	R̸ u+	R̸ u+	R̸	R̸	R̸		R̸
15	Urea, $(NH_2)_2CO$	R̸ U+	R̸,u+	R̸ u+	R̸ u+	R̸ u+	R̸ u+	R̸,u+[38]	R̸		R̸ u[39]
16	Amino acids[40] $RCH(NH_2)COOH$	R̸ u+	r rm,U+	r U+	r[9] U+ s	R̸,u+[41]	r u+	r u+	R U++	R,U++	R U++[11]
17	Peptides polypeptides[42]	R̸ u+	R̸ u+	R̸,u+	r,u+ s	R̸ u+	R̸ u+	r u+	R̸		R̸,U+
18	Proteins	R̸	R̸,u+	R̸	R̸,u+	R̸	R̸	r u+	R̸ U+	U+	R̸[43] U+,s
19	Imidazole compounds[44]	R̸	R̸,u+	R̸,u+	R̸ u+	R̸	R̸	R̸	R̸		R̸
20	Pyridine compounds[45]	R̸	R̸	r	r u+	R̸	R̸	r	r		r
21	Pyrimidine compounds[46]	R̸	R̸,u+ s	R̸ u+	R̸,u+ s	r	r	r u+	r		R
22	Purine compounds[47]	R̸ u	rm,u+ s	R̸ u	R̸,u+ s	R̸	R̸	r u+	R̸		R̸
23	Indole compounds[48]	R̸,	rm,u+	R̸	R̸ u+ s	R̸ s	R̸,s	R̸	R̸		R̸

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Including the colorless phytoflagellates /9/ Many bacteria R specific amino acids from the environment but as a class U NH_4^+ for synthesis of other amino acids /11/ Dietary NH_4^+ originating as metabolic intermediate U in amino acids synthesis /28/ Including hydroxylamine /29/ Hydroxylamine poor N-source /30/ Hydroxylamine U by Clostridium welchii U in non-toxic concentration by Nitrosomonas /31/ Hydroxylamine toxic. /32/ Alkylamines as methylamine CH_3NH_2 and arylamines as benzyl amine $C_6H_5CH_2NH_2$. /33/ Glucosamine U /34/ e g. Succinimide /35/ e g. Formamide $HCONH_2$ acetamide; also asparagine /36/ Acetamide U by some /37/ Formamide and others U by Aspergillus Both amino and amide N of asparagine U by Aspergillus /38/ U by Astasia longa (colorless phytoflagellate) /39/ U by ruminants via rumen microflora. /40/ See Table 2 /41/ L-arginine glutamine cysteine L-asparagine support more rapid growth of Chlorella than does NH_4^+ /42/ Including peptones synthetic di and tri peptides strepogenin" glutathione /43/ Proteins as such are listed as R̸ for vertebrates because only certain amino acids are actually R. /44/ e g. Allantoin creatinine guanidine /45/ e g. Niacin pyridine /46/ e g Pyrimidine, alloxan pyrimidine moiety of thiamine nucleic acids nucleotides /47/ e g. Uric acid caffeine theobromine nucleic acids nucleotides /48/ e g. Indole indoleacetate.

8 NUTRIENTS GENERAL CARBON SOURCES

R Required by all forms studied; Ɍ = Not required by any forms studied; U Utilized by all forms studied; Ʉ Not utilized by any forms studied
r Required by one or more species or strains; u Utilized by one or more species o strains; May serve as sole or partial C-source for one or more specie or strains; Simplest C-source for at least one of a group

	Groups of Organisms / Carbon Sources	Plants: Higher Green Plants[1]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Plants: Green Phytoflagellates[2]	Animals: Protozoa[3]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Inorganic										
1	Carbon amorphous C	Ʉ	u†	Ʉ	u*†	Ʉ	Ʉ	Ʉ	Ʉ		Ʉ
2	Carbon monoxide CO	Ʉ	Ʉ	Ʉ	u⁴	Ʉ†	Ʉ	Ʉ	Ʉ		Ʉ
3	Carbon dioxide CO_2	R U*†	r U		r u*†	R, U*†	r U*†	r u*5	U†		U
4	Bicarbonates $-HCO_3$	R U*†	U		u*†	U*†	r U*†	u*5	U†		U
5	Cyanogens $-CN^-$	?	u		u						
	Organic										
6	Alkanes alkenes	Ʉ	u	Ʉ	u⁶	Ʉ	Ʉ	Ʉ	Ʉ		Ʉ
7	Alcohols	u	u*	u	u	Ɍ u	Ɍ u		u		U
8	Aldehydes	Ɍ		u	u	Ɍ	Ɍ	Ɍ	Ɍ		Ɍ u
9	Ketones	Ɍ	Ʉ		u	Ɍ	Ɍ	u	Ɍ		Ɍ u
10	Acids	Ɍ	u*	u	u	Ɍ	Ɍ u	u	r U		r U
11	Carbohydrates	U⁷	U*	U*	U*	Ɍ u	Ɍ u	u⁸	r U		U
12	Glycosides	Ɍ	u		u	u	Ɍ u	Ɍ	Ɍ		Ɍ u
13	Fats	Ɍ Ʉ		u	u	Ɍ Ʉ	Ɍ Ʉ	u	r U⁹		U
14	Waxes	Ɍ Ʉ	u*		u	Ɍ Ʉ	Ɍ Ʉ	Ɍ Ʉ	u		u
15	Amino acids peptides/proteins	Ɍ u	u*	u	u	Ɍ	Ɍ u	u	u		R U

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Colorless phytoflagellates /4/ U by Carboxydomonas oligocarbophila and Methanosarcina barkeri /5/ U by Tetrahymena geleii condensation with pyruvate oxalacetate succinate; R by Chilomonas paramecium, Astasia longa (but not in acetate medium) Polytomella caeca on media containing casein hydrolysate also on acetate medium. /6/ U by Methanosarcina methanica; also U ethane propane butane hexane propylene butylene paraffin oils; U by Bacterium aliphaticum-liquefaciens: H_2 pentane hexane heptane octane decane cetylbenzol; U by others: gasoline kerosene mineral oils paraffin wax tar /7/ U by isolated tissue e g roots; callus and tumor tissues; by green plants in asepti culture /8/ Carbohydrate C-source Ɍ by Tetrahymena geleii except when utilizing NH_4^+ in medium low in amino acids /9/ Insects Ɍ dietary fats with exception of specific lipids as growth substances vitamins

9 NUTRIENTS GENERAL SULFUR SOURCES

Sulfur occurs in the amino acids cysteine cystine and methionine The last of these is required by all animal forms studied and may be an essential in the protein structure of all living organisms Sulfur occurs also in chondroitin sulfuric acid, a component of vertebrate connective tissue and in sulfo-lipids found in white matter of brain and in other tissues Emphasis is on utilization (U u) of a compound as a sulfur source

R = Required by all forms studied; R̸ = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U = Utilized by all forms studied; U̸ = Not utilized by any forms studied; u = Utilized by one or more species or strains

	Groups of Organisms / Sulfur and Sulfur Compounds	Plants: Higher Green Plants[1]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Green Phyto-flagellates[2]	Protozoa[3]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Sulfur source	R	R	R	R	R	R	R	R	R	R
	Inorganic Sulfur Sources										
2	Sulfur[4] (elemental) S	R̸,U̸	u[5]	u	r[6]	R̸,U̸	R̸	R̸	R̸		R̸,u[7]
3	Sulfhydryl, $-SH^-$	R̸	u			R̸	R̸	R̸	R̸		R̸
4	Sulfide $-S^=$	R̸	u[8]		u[9]	R̸,u[10]	R̸	R̸	R̸		R̸ U̸
5	Bisulfite $-HSO_3$	R̸	u[11]			R̸	R̸	R̸	R̸		R̸ U̸
6	Sulfite $-SO_3^=$	R̸ u	u[11]		u[12]	R̸	R̸	R̸	R̸		R̸ U̸
7	Sulfate $-SO_4^=$	U	u[11]	u	r	U	U	r	R̸		R̸ u[13]
8	Thiosulfate $-S_2O_3^=$	R̸ u	rm u		u[14]	R̸	R̸	R̸	R̸		R̸ U̸
9	$-S_2O_6^=$[15]	R̸	u			R̸	R̸	R̸	R̸		R̸
10	Tetrathionate, $-S_4O_6^=$	R̸			u	R̸	R̸	R̸	R̸		R̸
11	Sulfoxylate $-SOOH^-$	R̸	u[16]		u	R̸	R̸	R̸	R̸		R̸
12	$-SO$ as Sulfur hydrate, H_2SO	R̸			u	R̸	R̸	R̸	R̸		R̸
13	Thiocyanate, $-SCN^-$	R̸	u		u[17]	R̸	R̸	R̸	R̸		R̸
14	Persulfate	R̸	u[11]			R̸	R̸	R̸	R̸		R̸

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads, dinoflagellates /3/ Including the colorless phytoflagellates /4/ i e the substance not in combination with other elements /5/ U by Fusarium lini /6/ U by Thiobacillus thio-oxidans Sporovibrio desulfuricans s vestnarii, Chlorobiaceae /7/ Bacteria, in ruminants build the element into amino acids (methionine; cystine) /8/ Some aquatic fungi e g members of the Blastocladiales and Saprolegniales U̸ oxidized sulfur; these require a reduced sulfur source e g, H_2S, cysteine, cystine methionine thioacetate thiocarbonate thioglycolate thiourea. /9/ U e g, by Beggiatoa Thiothrix Thioploca, Thiobacilli /10/ Synechococcus grown in an atmosphere of H_2 U Na_2S (with reduction of CO_2); Oscillaria and Pinnularia also reduce CO_2 with H_2S depositing S in their cells Scenedesmus also U sulfide, H_2S toxic to Chlorella. /11/ U by Brevilagnea gracilis; U̸ by many other Saprolegniaceae /12/ U by Sporovibrio desulfuricans & vestnarii /13/ U for formation of chondroitin sulfate and heparin; U by laying hen by conversion to cystine /14/ U by Thiobacillus novellus Pseudomonas aeruginosa, Ps fluorescens Achromobacter stutzeri others /15/ Decomposes on contact with H_2O /16/ Inorganic sulfur less oxidized than sulfinate not efficiently U by Aspergillus niger /17/ NH_4SCN can be U by Bacillus thiocyano-oxidans as sole source of C N and S

GENERAL SULFUR SOURCES (Concluded)

Sulfur occurs in the amino acids cysteine cystine and methionine The last of these is required by all animal forms studied and may be an essential in the protein structure of all living organisms Sulfur occurs also in chondroitin sulfuric acid, a component of vertebrate connective tissue and in sulfo-lipids found in white matter of brain and in other tissues Emphasis is on utilization (U u) of a compound as a sulfur source

R Required by all forms studied; R̸ Not required by any forms studied; r Required by one or more species or strains; rm Required by one or more mutants; U = Utilized by all forms studied; U̸ Not utilized by any forms studied; u Utilized by one or more species or strains

	Groups of Organisms / Sulfur and Sulfur Compounds	Plants: Higher Green Plants[1]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Plants: Green Phytoflagellates[2]	Animals: Protozoa[3]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Sulfur Containing Amino Acids Sulfoproteins[18]										
15	Cystathionine	R̸	u		u	R̸	R̸	R̸ u	u		u
16	Cysteine	R̸ u	u[8]	u	r	R̸ u[19]	R̸ u	u	u[20]		U
17	Cystine	R̸ u	u[8]	u	r	R̸	R̸ u	u	u		U
18	Homocysteine	R̸	U		u	R̸	R̸	R̸ u	u		u
19	Homocystine	R̸	U		u	R̸	R̸	R̸ u	u		u
20	Methionine	R̸ u	U	u	r	R̸ U̸	r	r	r[21]		R
21	Peptones	R̸ u	U	u	u	R̸ u	u	r	u		R̸ U
	Sulfur Containing Vitamins and Growth Factors[18]										
22	Biotin[22]	R̸	u	u	u	R̸	r	r?	r		R?U
23	Coenzyme A	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸		R̸ U
24	Glutathione ("G-SH")[23]	R̸	u	u	r	R̸	u	R̸ u	r		R̸ U
25	Thiamine[24]	R̸	U̸	r	r	u	r	r	r		R
26	Thiazole[24]	R̸	ur[25]	r[26]	r[26]	r	r[26]	r[26], u	R̸		R̸
27	Thioctic acid[27]	R̸	R̸	R̸	r[28]	R̸	R̸	r[29]	R̸		R̸
	Other Sulfur Sources										
28	Miscellaneous compounds[30]										

/1/ Spermatophytes (the intact plant) /2/ Green phytoflagellates chrysomonads dinoflagellates /3/ Including the colorless phytoflagellates /8/ Some aquatic fungi e.g. members of the Blastocladiales and Saprolegniales R̸ oxidized sulfur; these require a reduced sulfur source e g H_2S cysteine cystine methionine thioacetate thiocarbonate thioglycolate thiourea. /18/ R r U u may mean as a sulfur source or the compound may be R for its molecular structure, not synthesized by the organism. /19/ U as N-source (and sulfur source?) by Chlorella pyrenoidosa. /20/ Also U cysteic acid isethionic acid. /21/ Also U methionine sulfoxide taurine /22/ Biotin R by numerous fungi yeasts bacteria and by most of the vertebrates and invertebrates studied The replacement of S in the biotin molecule does not affect the activity for some bacteria. /23/ Complex of cysteine glycine and glutamic acid. /24/ Thiamine containing pyrimidine and thiazole (the latter an imidazole ring with one C replaced by sulfur) is R by numerous organisms probably also a sulfur source? /25/ R̸ as sulfur source by Aspergillus niger (cannot rupture the thiazole ring?) /26/ Satisfies thiamine requirement for some (cf Fn 24); probably a sulfur source? /27/ Protogen or α-lipoic acid /28/ R by Streptococcus faecalis for oxidation of pyruvate /29/ R by Tetrahymena geleii (8 strains) T vorax (2 strains) /30/ Many compounds containing S have been tested on a wide variety of organisms Typical of these compounds are the alkylsulfides sulfinates and sulfonates; the sulfoxides, sulfamates and sulfonic acid amides; ethereal sulfates; taurine; the thiols and thio-compounds: -acetamide -acetate -carbonate -glycolate -oxalate, -urea. Many of these are U by some fungi and bacteria and certain of the thio-salts are R by some fungi Most of these S-containing compounds are R̸ by plants algae green phytoflagellates protozoa invertebrates and vertebrates

10 UTILIZATION OF CHEMICAL ELEMENTS INSECTS

All species of insects utilize nitrogen, carbon, oxygen and hydrogen which in various molecular combinations constitute the structure of their bodies and their food. In addition phosphorus, sulfur, iron, copper, magnesium, manganese, potassium, calcium and chlorine are probably universal requirements of insects. A number of different minerals, some only as traces, also are consumed and are found present in the constitution of the insect. One can suppose that the mineral composition of the insect may influence considerably the chemical reactions taking place in the tissues but it is difficult to ascertain whether or not some of these trace elements are utilized specifically. The present data are taken mainly from studies in which the insect is noticeably affected by the presence or absence of mineral element in its rearing medium or food.

Utilized (U); Not Utilized (N)

Element \ Organism	Orthoptera		Coleoptera	Lepidoptera					Diptera									Homoptera	Siphonaptera
	Cockroach, American, adult (Periplaneta americana (L.))	Grasshopper, egg (Melanoplus differentialis)	Beetle, confused flour, larva (Tribolium confusum Duv.)	Leafworm, cotton, larva (Alabama argillacea (Hbn.))	Moth, larva	Moth, larva (L.)	Silkworm, larva (Bombyx mori (L.))	Silkworm, adult (Bombyx mori (L.))	Fly, flesh, larva (Sarcophaga)	Fly, fruit, larva (Drosophila melanogaster)	Fly, greenbottle, larva (Lucilia sericata (Meig.))	Fly, house, adult (Musca domestica (L.))	Mosquito, larva	Mosquito, larva (Aedes aegypti (L.))	Mosquito, larva (Culex pipiens)	Mosquito, larva (Theobaldia incidens (Thom.))	Parasite of spruce bud worm, larva (Pseudosarcophaga affinis)	Aphid, rose (Macrosiphum rosae (L.))	Flea, rat, larva (Nosopsyllus fasciatus (Bosc))
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
1 Antimony	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2 Calcium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3 Carbon[5]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4 Chlorine	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5 Cobalt	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6 Copper	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7 Hydrogen[5]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8 Iron	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9 Lead	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10 Magnesium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11 Manganese	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12 Mercury	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13 Nickel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14 Nitrogen[5]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15 Oxygen[5]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16 Phosphorus[5]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17 Potassium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18 Sodium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19 Sulfur[5]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20 Tin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21 Zinc	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

/2/ Utilization judged by effect of the element on fecundity. /3/ Utilization judged by influence of the element on occurrence of alate forms. /4/ Reported by some (q.) as not utilized by Drosophila except possibly in trace amounts. /5/ In balanced solution only. /5/ Universal constituent of protoplasm. /6/ Absent from chemically defined nutrient medium except as hydrochlorides of amino-acids or vitamins. /7/ Toxic for this organism. /8/ Based on non-utilization of cobalamin. /9/ As $Pb(NO_3)_2$. /10/ Replaceable by magnesium. /11/ Utilized as KCN but not as KCl. /12/ Absent from the chemically defined nutrient medium except as occurring in sulfur containing amino acids.

11 UTILIZATION OF PROTEINS INSECTS

		Utilized (U)														
	Organism / Protein	Orthoptera	Coleoptera								Lepidoptera				Diptera	
		Cockroach, German, nymph (Blattella germanica (L.))	Beetle, carpet, larva (Attagenus (sp.))	Beetle, cigarette, larva (Lasioderma serricorne (Fab.))	Beetle, confused flour, larva (Tribolium confusum Duv.)	Beetle, drugstore, larva (Stegobium paniceum (L.))	Beetle, hide, larva (Dermestes maculatus Deg.)	Beetle, saw toothed grain, larva (Oryzaephilus surinamensis (L.))	Beetle, spider, larva (Ptinus tectus Boield)	Mealworm, yellow, larva (Tenebrio molitor L.)	Corn borer, European, larva (Pyrausta nubilalis (Hbn.))	Moth, Mediterranean flour, larva (Ephestia kuehniella Zell.)	Moth, tobacco, larva (Ephestia elutella (Hbn.))	Moth, webbing clothes, larva (Tineola bisselliella (Hum.))	Fly, vinegar fruit, larva (Drosophila melanogaster Meig.)	Mosquito, yellow-fever, larva (Aedes aegypti (L.))
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)
1	Proteins total[1]	15-30%	6-12%	45%	15-45%	45%		45%	45%	15-45%	20-30%	45%	20%	20-80%	2 5%	
2	Brain protein[2]				U[3]		U[3]			U[3]						
3	Casein	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U	U[3]	U[3]	U[3]	U[3]	U[3]
4	Cotton seed protein				U[3]		U[4] 5			U[4]						
5	Edestin[6]				U[4]					U[4]						
6	Fibrin[7]	U[3]			U[3]		U[3]			U[4]	U[8]					
7	Gelatin	U[4]			U[8]					U[8]					U[8]	
8	Gliadin[9]				U[4]					U[8]						
9	Gluten wheat	U[4]			U[3]					U[3]	U[8]					
10	Glycinin[10]				U[3]		U[4]			U[3]						
11	Hemoglobin	U[4]														
12	Lactalbumin[11]	U[4]		U[3]	U[3]		U[3]			U[3]	U[8]					
13	Liver Protein				U[3]		U[3]			U[3]						
14	Peanut protein				U[3]		U[3]			U[3]						
15	Soybean protein				U[3]		U[3] 8			U[4]						
16	Zein[12]	U[8]			U[4]		U[8]			U[8]	U[8]					

/1/ Percentage of protein in diet required to maintain growth and development /2/ Wilson B protein /3/ maintains good growth and development /4/ Maintains only poor growth and development /5/ Only when heated. /6/ A complete globulin from hemp seed. /7/ From blood. /8/ Maintains little or no growth and development /9/ A protein separable from wheat gluten. /10/ A globulin constituting 90-95% of protein content of soy bean. /11/ From milk /12/ An alcohol soluble protein from maize (corn)

AMINO ACID REQUIREMENTS MAN AND OTHER VERTEBRATES

Values are considered adequate fo satisfactory growth or maintenance o recovery from protei depletion as speci fied in the column headings Twice the values should give an acceptable margin of safety where such is desired (cf also Pa 4) Presentation of values in terms of per kg body weight pe day" is for purposes of comparison of speci s and does not necessarily imply close correlation between nutrient need and body weight withi the species

	Specifications / Amino Acid per kg body weight per day	Man[3,4]	Essential[1] (R); Utilised[2] (U)								
			Rat[5]			Mouse	Chicken[6]	Turkey[7]	Dog[8]		Swine[9]
		Adult	Young[10]	Adult	Adult	Young	Young[11]	Young	Young[12]	Adult[13]	Young
		♂70 kg	♂0 05 kg	0.15 kg	0.15 kg	0 025 kg	♂0.85 kg	♂0 58 kg	♂1 5 kg	♂7 kg	♂9.45 kg
		Nitrogen Balance	Growth	Maintenance	Repletion[14]	Growth	Growth	Growth	Growth	Nitrogen Balance[15]	Growth
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	L-Alanine	U	U	U	U						
2	L-Arginine mg	U	R900[16]	U	U	?	R1870	R1600	270[17]	70[17]	R155
3	L-Aspartic acid	U		U	U						
4	L-Citrulline	U									
5	L-Cystine mg	U	U[18]	U	U		R1540[19]	U320[19]			
6	L-Glutamic acid	U	U[20]	U	U						
7	Glycine mg	U	U	U	U		R1560	R1000			
8	L-Histidine mg	U	R1600	R35	R120	R	R250		60[17]	25[17]	R260
9	L-Hydroxyproline	U	U		U						
10	L-Isoleucine mg	R10	R1800	R180	R345	R	R930	R860	330[17]	80[17]	R520
11	L-Leucine mg	R15.5	R2750	R110	R415	R	R2180		370[17]	110[17]	R520
12	L-Lysine mg	R11.5	R2750	R60	R330	R	R1400	R1400	[illegible]	60[17]	R650
13	L-Methionine mg	R15.5	R1800	R90	R220	R	R700	R520	210[17]	70[17]	R590
14	L-Phenylalanine mg	R15.5	R2750	R50	R255	R	R1400		190[17]	65[17]	R580
15	L-Proline	U	U[20]								
16	L-Serine	U	U								
17	L-Threonine mg	R7	R1600	R65	R445	R	R930		140[17]	55[17]	R260
18	L-Tryptophan, mg	R3.5	R900	R30	R80	R	R310	R270	60[17]	15[17]	R130
19	L-Tyrosine mg	U	U[21]	U	U		R1090				
20	L-Valine mg	R11.5	R2500	R120	R290	R	R1240		300[17]	85[17]	R260

/1/ An essential amino acid (R) is an indispensable component of the diet because it is not synthesised from materials ordinarily available at speed sufficient for maintenance of nitrogen balance in the adult and/or normal growth in the young. /2/ A non-essential amino acid can be synthesised in adequate amount in the body from other nitrogen sources if not supplied in the diet Non-essential amino acids can be utilised by man and probably by most other vertebrates /3/ To obtain recommended intake per person (adult) per day multiply values by 70 regardless of actual weight unless it represents an extreme departure from 70 kg. Rose W C. finds that requirement does not vary with weight in adult male /4/ The values in this column represent the minimum requirements as determined for young healthy males; twice these values i considered safe" allowance for normal healthy males and females but they probably should be increased more than twice for growth, rehabilitation from disease and during pregnancy and lactation. /5/ White rat /6/ New Hampshire Values in this column are based on a daily food intake of 99 grams per chick. /7/ Broad Breasted Bronze Values in this column are based on daily food intake of 56 grams per turkey /8/ Cocker spaniel. /9/ Values in this column are based on syntheti diet with amino acids and diammonium citrate as nitrogen sources /10/ Values in this column calculated on basis of 10 grams daily food intake per rat and with cystine and tyrosine lacking in diet /11/ Amino acid requirement i increased when protein intake i raised. /12/ Amino acids supplied from egg proteins /13/ Amino acids supplied by egg albumin. /14/ Values in this column represent allowances for rapid weight recovery and protein repletion in adult protein-depleted rats /15/ Values in this column represent the minimum nitrogen intake that maintained nitrogen balance /16/ Synthesized by the rat but not at sufficient speed for maximum growth. /17/ Data available do not make clear whethe all or these amino acids are indispensable or not /18/ Cystine may replace one sixth of the methionine requirement /19/ If not supplied in diet the daily allowance of methionine must be increased correspondingly /20/ Either glutamic acid or proline may substitute partially for arginine /21/ If tyrosine is present the phenylalanine requirement may be decreased.

13 AMINO ACID REQUIREMENTS INSECTS

Required (R); Not required (R̸)

Organism / Amino Acid[1]	Orthoptera: Cockroach German; nymph (Blattella germanica (L))	Coleoptera: Beetle carpet; larva (Attagenus (sp))	Coleoptera: Beetle, confused flour larva (Tribolium confusum Duv)	Coleoptera: Beetle, hide; larva (Dermestes maculatus Deg)	Coleoptera: Mealworm, yellow; larva (Tenebrio molitor L)	Diptera: Fly green bottle; larva (Phoenicia sericata Meig)	Diptera: Fly fruit vinegar; larva (Drosophila melanogaster Meig)	Diptera: Mosquito, yellow fever; larva (Aedes aegypti (L))	Diptera: Parasite of spruce budworm; larva (Pseudosarcophaga affinis (Fall))
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1 Alanine	R	R̸	R̸				R̸	R̸	R̸
2 Arginine	R	R	R[2]				R[3]	R	R
3 Aspartic acid	R̸	R̸	R̸				R̸	R̸	R̸
4 Cystine	R?	R̸	R̸	R		R	R̸	R?	R̸
5 Glutamic acid	R̸	R̸	R̸				R̸	R̸	R̸
6 Glycine	R̸	R̸	R̸				R̸[4]	R	R
7 Histidine	R	R	R[2]				R	R	R
8 Hydroxyproline	R̸	R̸	R̸				R̸	R̸	R̸
9 Isoleucine	R	R	R[2]				R	R	R
10 Leucine	R	R	R[2]				R	R	R
11 Lysine	R	R	R[5]		R		R	R	R
12 Methionine	R?[6]	R	R[5]				R	R	R
13 Norleucine		R̸							
14 Phenylalanine	R̸	R	R[5]				R	R?	R
15 Proline	R[7]	R̸	R̸				R̸	R̸	R̸
16 Serine	R[7]	R̸	R̸				R[8]	R̸	R̸
17 Threonine	R̸	R	R[2]				R	R	R
18 Tryptophan	R?	R	R[2]		R		R	R	R
19 Tyrosine	R̸	R̸	R̸				R̸	R̸?	R̸
20 Valine	R	R	R[2]				R	R?[9]	R

/1/ Diets containing all amino acids produce slightly better growth than mixtures of required constituents alone L-forms are biologically active /2/ D-form of the amino acid inactive /3/ Citrulline can partially substitute for arginine /4/ Required for maximal growth /5/ D-form of the amino acid active /6/ In non-sterile cultures /7/ Required by males only /8/ D-Serine extremely toxic and L-Serine slightly toxic /9/ Requirement or lack of requirement not demonstrated since valine was present in yeast extract, one of the ingredients of the medium

14 UTILIZATION OF CARBOHYDRATES INSECTS

Utilized (U); Poorly utilized (±); Not utilized (∅); Not required (Ø)

Carbohydrate \ Organism	Isoptera: Termite; adult (defaunated) (Zootermopsis angusticollis (Hagen))	Orthoptera: Cockroach, German; nymph (Blattella germanica (L.))	Orthoptera: Grasshopper, two-striped; adult (Melanoplus bivittatus (Say))	Coleoptera: Beetle, carpet; larva (Attagenus (sp.))	Coleoptera: Beetle, cigarette; larva (Lasioderma serricorne (L.))	Coleoptera: Beetle, confused flour; larva (Tribolium confusum Duv.)	Coleoptera: Beetle, drug-store; larva (Stegobium paniceum (L.))	Coleoptera: Beetle, powder-post; larva (Lyctus (sp.))	Coleoptera: Beetle, saw-toothed grain; larva (Oryzaephilus surinamensis (L.))	Coleoptera: Beetle, spider; larva (Ptinus tectus Boield)	Coleoptera: Mealworm, yellow; larva (Tenebrio molitor L.)	Coleoptera: Weevil, cowpea; larva (Callosobruchus maculatus (F.))	Lepidoptera: Butterfly, European cabbage; larva (Pieris brassicae (L.))	Lepidoptera: Butterfly, small tortoise-shell; larva (Aglais urticae (L.))	Lepidoptera: Cornborer, European; larva (Pyrausta nubilalis (Hbn.))	Lepidoptera: Moth, buff tip; larva (Phalera bucephala (L.))	Lepidoptera: Moth, wax; larva (Galleria mellonella (Walker))
1 Carbohydrates	U	30%[1]	U	∅	±–∅	Ø[2]	30%[1]	U	U	±–Ø[2]	80–85%[1]	U			85%[1]	50–80%[1]	50%[1]
2 Adonitol																	
3 Arabinose						∅	∅		∅		∅						
4 Arabitol																	
5 Cellobiose						U[3]†					±						
6 Cellulose	∅	∅					∅	∅	∅						∅	∅	
7 Dextrin		U	±			±[3]†			±		U						
8 Dulcitol											∅						
9 Erythritol																	
10 Fructose	U					∅[4]	∅[4]		U		∅[4]				U		U[5]
11 Fucose																	
12 Galactose	U		U			∅	∅		∅		∅						
13 Glucose	±	±	U		U	U	U	U	U	±	U		U	U	U	±	U
14 Glycerol																	
15 Glycogen			±								±						
16 Hemicellulose								∅									
17 Inositol		∅															
18 Inulin			±			U[3]†	∅		∅		∅						
19 Lactose	U	±				∅	∅		U		±				∅		
20 Lyxose																	
21 Maltose	U					±	U		U		U				∅		
22 Mannitol						U	U		±		±						
23 Mannose						∅	∅				∅[4]						
24 Melezitose																	
25 Melibiose						U[3]†											
26 β-Methyl fructopyranoside																	
27 α-Methyl galactoside																	
28 β-Methyl galactoside																	
29 α-Methyl glucoside						∅	±†		∅		∅						
30 β-Methyl glucoside											∅						
31 α-Methyl mannoside																	
32 Raffinose						U	U		∅		U						
33 Rhamnose						U[3]†											
34 Ribose											∅						
35 Sorbitol						±	∅[5]		U		U[4]						
36 Sorbose						∅	∅		∅		∅						
37 Starch	±	U	±		±	±	U	±	±	U	U		∅	∅	∅	∅	∅
38 Sucrose	U	U			±†	∅	∅	U	∅		U	U[6]	U	U	±	U	
39 Trehalose																	
40 Xylose			±			∅	∅		∅								
41 Other polysaccharides	∅																

[1] Approximate percentage of carbohydrate required in optimum diet. [2] Grows fairly well in absence of carbohydrates. [3] Not fully utilized. [4] Hygroscopic; renders diet unsuitable for growth and survival. [5] Has retarding effect on growth. [6] Sugar presumably sucrose.

UTILIZATION OF CARBOHYDRATES INSECTS (Concluded)

Utilized (U); Poorly utilized (u); Not utilized (N); Not required (∅)

Carbohydrate \ Organism	Lepidoptera (concluded)							Diptera								Hymenoptera	
	Moth Indian-meal, larva (Plodia interpunctella (Hbn.))	Moth ?, larva (Anomis? ?)	Moth, leafy, larva (Malacosoma neustria (L.))	Moth Mediterranean-flour, larva (Ephestia kuehniella Zell.)	Moth, tobacco, larva (Ephestia elutella (Hbn.))	Moth webbing-clothes, larva (Tineola bisselliella (Hum.))	Worm Southern Army, larva (Prodenia eridania (Cram.))	A parasite of spruce budworm, larva (Pseudosarcophaga affinis (Fall.))	Blowfly, adult (Calliphora erythrocephala Meig.)	Blowfly, black, adult (Phormia regina Meig.)	Fly, house, adult (Musca domestica L.)	Fly, Mexican-fruit, adult (Anastrepha ludens (Loew))	Fly, horse-bot, larva (Gasterophilus intestinalis (Deg.))	Fly, vinegar fruit, adult (Drosophila melanogaster Meig.)	Mosquito, yellow-fever, larva (Aedes aegypti (L.))	Bee, honey, adult (Apis mellifera L.)	Bee, honey, larva (Apis mellifera L.)
(A)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(AA)	(BB)	(CC)	(DD)	(EE)	(FF)	(GG)	(HH)	(II)
1 Carbohydrates	50%[1]	U	U	80%[1]	50%[1]	U-N[7]	U	U	U	U	U	U		U	U	N	U
2 Adonitol														u			
3 Arabinose									N	u		N		u	N	u	
4 Arabitol														N			
5 Cellobiose									N	u		N		N	N[7]	u	
6 Cellulose																	
7 Dextrin				U					u			U		u		N	U[7]
8 Dulcitol										u				N	U[7]	N	
9 Erythritol									N			N		N		N	
10 Fructose	U[5]			U	U[5]				U	U		U	U	U	U[7]	U	u
11 Fucose									N	N				u		N	
12 Galactose				N					U	U		U			U[7]	u	N
13 Glucose	U	U[7]	U[5,7]	U	U	U[8]	U	U	U	U		U		U	U[7]	U	U[7]
14 Glycerol									u	u				N		U	
15 Glycogen									u					u			N
16 Hemicellulose																N	
17 Inositol						N			N	u						N[7]	
18 Inulin				N					N[7]					N		N	
19 Lactose				N					u			N			U[7]	N	N
20 Lyxose									N	u							
21 Maltose				U					U	U		U		U	U[7]	U	U
22 Mannitol				N					U			N		u	N[7]	U	
23 Mannose									N	U		N		U	N[7]	N[9]	
24 Melezitose									U	U		U		U		U	N
25 Melibiose									U					U		N	
26 β-Methyl fructopyranoside									N								
27 α-Methyl galactoside									U						u		
28 β-Methyl galactoside									N								
29 α-Methyl glucoside				N					U	u				u	U[7]	U	
30 β-Methyl glucoside									N								
31 α-Methyl mannoside									N								
32 Raffinose				N					U	U		U		U	N	U[7]	
33 Rhamnose									N	u		N		N	N	u	
34 Ribose				U					U[10]	U				u	N[7]	U	
35 Sorbitol																	
36 Sorbose				N					N	u					N	N	
37 Starch	N	N	u[7]	U[5]	N	U[5] [6]	N				N			u[7]	U		N
38 Sucrose			U[7]	N			U[5,7]		U	U	U	U		N	U	U	U
39 Trehalose									U	U		U		U	u[7]	N	U
40 Xylose				N					u	u		N			u[7]	U[5,7]	
41 Other polysaccharides																U	

/1/ Approximate percentage of carbohydrate required in optimum diet. /5/ Not fully utilized. /6/ Has retarding effect on growth. /7/ Reducing sugars. /8/ Utilized but not required. /9/ Toxic for this organism. /10/ Utilized by this organism better than any other sugar

15 UTILIZATION OF LIPIDS INSECTS

Required (R); Not required (R̸); Utilized (U); Poorly utilized (u); Not utilized (U̸)

	Lipid (A)	Orthoptera, Nymph: Cockroach, German (Blattella germanica (L.)) (B)	Coleoptera, Larva: Beetle, carpet (Attagenus (sp.)) (C)	Beetle, cigarette (Lasioderma serricorne (Fab.)) (D)	Beetle, confused-flour (Tribolium confusum Duv.) (E)	Beetle, drug store (Stegobium paniceum (L.)) (F)	Beetle, hide (Dermestes maculatus Deg.) (G)	Beetle, saw-toothed grain (Oryzaephilus surinamensis (L.)) (H)	Beetle, spider (Ptinus tectus Boield.) (I)	Cowpea weevil (Callosobruchus chinensis L.) (J)	Mealworm, yellow (Tenebrio molitor L.) (K)	Lepidoptera, Larva: Corn borer, European (Pyrausta nubilalis (Hbn.)) (L)	Moth, fig (Ephestia cautella (Wlkr.)) (M)	Moth, Indian-meal (Plodia interpunctella Hbn.) (N)	Moth, Mediterranean-flour (Ephestia kuehniella Zell.) (O)	Moth, tobacco (Ephestia elutella (Hbn.)) (P)	Moth, webbing-clothes (Tineola bisselliella (Hum.)) (Q)	Diptera, Larva: Fly, greenbottle (Phoenicia sericata (Meig.)) (R)	Fly, vinegar fruit (Drosophila melanogaster Meig.) (S)	Mosquito, yellow-fever (Aedes aegypti (L.)) (T)
1	Lipids, general	U		U^{1}	U^{1}	U^{2}	U^{2}	U^{1}	u	U	U		U^{2}	U^{2}	U^{2}	U^{2}	U	U	U	U^{1}
	Lipids, nerve tissue																			
2	Cephalin																			U̸
3	Kerasin																			u
4	Lecithin																			U^{3}
5	Sphingomyelin																			u
	Fats, mixed																			
6	Butter fat												u	u	u	u		U		
7	Cod liver oil												U		U	U				
8	Corn oil	R^{4}																		
9	Wheat-germ oil				U^{2}								U	U	$U^{2,5}$	U^{1}	U			
10	Yeast oil												U		U̸	U				U^{2}
	Triglycerides																			
11	Triolein																			U̸
12	Tripalmitin																			U̸
13	Tristearin																			U̸

For footnotes see following page

14	Fatty Acids	U̸	U̸	U̸	U̸	U̸	U̸	U̸	U̸		U̸	R[6]	R	U̸	R[6]	R[6]	U̸		U̸	U̸
15	Arachidonic acid														u[6,7,8?]					
16	Docosahexaenoic acid														U̸[8]					
17	Lauric acid																			U̸[8]
18	Linoleic acid											U	U[5,6]		U[5,6,10]	U[5,6]				U̸
19	Linolenic acid														U[5,6]	U				U̸
20	Myristic acid																			U̸[8]
21	Oleic acid														U̸	U̸				U̸[8,9]
22	Palmitic acid																			U̸
23	Stearic acid																			U̸
24	Sterols, derivatives	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
25	Calciferol			U̸	U̸	U̸	U̸	U̸?	U̸		U̸				U̸				U̸	U̸
26	Cholestanol		U̸	u	u?	U?	U̸	U	u	U					u?				u	u
27	B-Cholestanol		U̸							U̸										
28	Cholestene				u?	U̸	U̸			U					U̸					
29	Cholesterol	U[11]	U	U[2]	U[2,11]	U[2]	U[2]	U[2]	U[2]		U[2]	U[6]	U[2]	U[2]	U[2]	U[2]	U[2]	U[2]	U[2]	U[2]
30	Cholesterol, 7-dehydro-		U	U[2]	U[2]	U[2]	U[12]	U[2]	U[2]						U[2]					
31	Cholesterol, 7 hydroxy		U̸		u?	U̸	U̸[12]								U̸					U̸
32	Cholesterol dibromide		u?																	
33	Cholesteryl acetate		U		U[2]	U[2]	U[12]			U̸					U[2]					
34	Cholesteryl acetate, 7 keto-		U̸		U̸	U̸	U̸[12]								U̸					
35	Cholesteryl chloride		U̸							U̸										
36	Cholesteryl dibenzoate, 7-hydroxy				U̸?	U̸	U̸[12]								U̸					
37	Cholesteryl monobenzoate 7-dehydro-				u?[12]	U̸	U[12]								U̸					
38	Cholesteryl monobenzoate 7 hydroxy				u	U̸	U								U̸					
39	Coprostanol																			u
40	Ergosterol		u	U[2]	U[2]	U[2]	U̸[12]	U[2]	U[2]		U[2]				u?				U[2]	u
41	Phytosterol									U	U[2,12]									
42	Sitosterol			U[2]	U[2]	U[2]	U̸[12]	U[2]	U[2]	U	U[2]				U[2]				u	U[2]
43	Stigmasterol																		u	U[2]
44	Zymosterol			u[12]	U̸?[12]	U̸	U̸[12]	U?[12]	u[12]						U̸				u	u
45	"Tween 80"[13]																		U̸	

/1/ Utilized, but reduced growth and limited metamorphosis can occur in the absence of lipids /2/ Lipid fully utilized /3/ Can partially replace biotin /4/ 3% required in optimum diet /5/ Affects wing scale formation /6/ Alpha tocopherol or other antioxidants required in the diet along with this constituent /7/ Not utilized, but affects wing scale formation /8/ Not required, but improves growth /9/ Toxic for this organism. /10/ 0.25 0 3% required in optimum diet /11/ 1% required in optimum diet /12/ Lipid contained impurities /13/ Sorbitan monooleate a polyoxalkylene derivative

16 ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS INSECTS

No insects are known to require vitamins A C D, or K or the provitamins of D or K. Vitamins reported to be beneficial but not required are listed as required. An entry followed by a question mark indicates the preponderance of evidence among conflicting bibliographic sources

Required (R); Not required (~~R~~)

Organism / Compound	Orthoptera	Coleoptera											
	Cockroach German[1] larva (Blattella germanica (L.))	Beetle carpet, larva (Attagenus sp.)	Beetle cigarette, larva (Lasioderma serricorne (Fab.))	Beetle cigarette[2] adult (Lasioderma serricorne (Fab.))	Beetle confused flour larva (Tribolium confusum Duv.)	Beetle drug store adult (Stegobium paniceum (L.))	Beetle drug store[2] larva (Stegobium paniceum (L.))	Beetle hide larva (Dermestes maculatus Deg.) Also known as D. vulpinus	Beetle red flour, larva (Tribolium castaneum Herbst)	Beetle saw toothed grain (Oryzaephilus surinamensis (L.))	Beetle small-eyed flour larva (Palorus ratzeburgi Wissmann)	Beetle spider larva (Ptinus tectus Boield)	Meal worm yellow larva (Tenebrio molitor L.)
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)
1 Biotin	~~R~~?	R	R?	R	R	R?	R	R	R	~~R~~	R?	R	R
2 Carnitine[3]											R		R
3 Choline	R[4]	R	R?	R	R	~~R~~?	R?	R		~~R~~	R	R	~~R~~?
4 Cobalamin[5]													
5 Vitamin E													
6 Folic acid group[6]	~~R~~	R	~~R~~	R	R	~~R~~?	R	R	R		R?		R
7 Inositol	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~?	~~R~~		~~R~~	~~R~~	~~R~~?	~~R~~
8 Niacin[7]	R	R	~~R~~	R	R	~~R~~	R	R	R	R	R	R	R
9 Pantothenic acid	R	R	~~R~~?	R	R	~~R~~	R	R	R	R	R	R	R
10 Para-aminobenzoic acid	~~R~~	~~R~~	~~R~~?	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~		~~R~~	~~R~~	~~R~~?	~~R~~
11 Pyridoxine group[8]	R	R	~~R~~?	R	R	~~R~~	R	R	R	~~R~~	R	R	R
12 Riboflavine	R	R	~~R~~	R	R	~~R~~	R	R	R	R	R	R	R
13 Thiamine	R	R	~~R~~	R	R	R	R	R	R	~~R~~	R	R	R
14 Cholesterol[9]	R	R	R	R	R	R	R	R		R		R	R
15 Linoleic acid													~~R~~
16 Other substances	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	R[10]	R	~~R~~	~~R~~	~~R~~	~~R~~

/1/ Aseptically reared on synthetic diets /2/ Deprived of normally present intracellular symbiotes /3/ Vitamin B_T /4/ May be replaced by betaine /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product known variously as B_{12a} or B_{12b} which has approximately the same biological activity /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c factor U L. casei factor Norite eluate factor /7/ Used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide) /8/ Includes pyridoxine, pyridoxal pyridoxamine /9/ Cholesterol may be required by all the forms listed but is shown as required only in those forms in which specific experiments have indicated its need. /10/ Unidentified substances obtained from yeast

16 ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS INSECTS (Concluded)

No insects are known to require vitamins A C D or K or the provitamins of D or K. Vitamins reported to be beneficial but not required are listed as required. An entry followed by a question mark indicates the preponderance of evidence among conflicting bibliographic sources

Required (R); Not required (R̸)

	Compound (A)	Lepidoptera: Cornborer European[1] larva (Pyrausta nubilalis (Hbn)) (O)	Lepidoptera: Moth Indian meal larva (Plodia interpunctella Hbn) (P)	Lepidoptera: Moth Mediterranean flour larva (Ephestia kuehniella Zell.) (Q)	Lepidoptera: Moth rice larva (Corcyra cephalonica St) (R)	Lepidoptera: Moth tobacco larva (Ephestia elutella (Hbn)) (S)	Lepidoptera: Moth wax larva (Galleria mellonella L.) (T)	Lepidoptera: Moth webbing clothes larva (Tineola bisselliella (Hum)) (U)	Diptera: Blowfly larva (Phoenicia sericata (Meig)) (V)	Diptera: Fly vinegar fruit[1] larva (Drosophila melanogaster Meig) (W)	Diptera: Mosquito house[1] larva (Culex pipiens L.) (X)	Diptera: Mosquito yellow fever[1] larva (Aedes aegypti (L.)) (Y)	Diptera: Parasite of spruce budworm[1] larva (Pseudosarcophaga affinis (Fall.)) (Z)	Hymenoptera: Bee honey (Apis mellifera L.) (AA)
1	Biotin		R	R		R		R?	R̸	R		R[11]	R	
2	Carnitine[3]									R̸				
3	Choline	R		R		R		R	R	R		R	R	
4	Cobalamin[5]									R̸[12]			R̸	
5	Vitamin E			R										
6	Folic acid group[6]		R[13]	R[13]		R[13]			R̸	R̸		R	R̸	
7	Inositol			R		R̸		R̸	R̸	R̸		R̸?	R̸	
8	Niacin[7]			R		R	R	R	R	R	R̸	R	R	R
9	Pantothenic acid			R		R		R	R	R		R	R̸	
10	Para-aminobenzoic acid			R̸		R̸		R̸	R̸	R̸		R̸?	R̸	
11	Pyridoxine group[8]			R	R	R		R	R	R		R	R̸	
12	Riboflavine			R	R	R		R	R	R	R	R	R	R
13	Thiamine			R	R	R	R	R	R	R	R	R	R	
14	Cholesterol[9]		R	R	R	R			R	R		R		
15	Linoleic acid		R̸	R		R								
16	Other substances	R[14]	R[10]	R̸?	R[10]	R̸?	R̸	R̸			R[15]	R[16]	R	R[10]

/1/ Aseptically reared on synthetic diets /3/ Vitamin B_t /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product known variously as B_{12a} or B_{12b} which has approximately the same biological activity /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (Folacin) vitamin M vitamin B_c factor U L. casei factor Norite eluate factor /7/ Used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide) /8/ Includes pyridoxine pyridoxal pyridoxamine /9/ Cholesterol may be required by all the forms listed but is shown as required only in those forms in which specific experiments have indicated it need. /10/ Unidentified substances obtained from yeast /11/ May be partially replaced by lecithin oil from hydrolized plasma (PHP)or oleic acid. /12/ Cobalamin addition produces higher percentage of pupation. /13/ May be replaced by an increased amount of xanthopterin. /14/ Unidentified substance obtained from yeast and cornleaves /15/ Unidentified substances obtained from yeast or liver /16/ Glutathione and unidentified substance obtained from yeast and liver

17 ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS PROTOZOA

Required (R); Not Required (R̸)

	Species	Ciliata									Flagellata																				Sarcodina	Sporozoa
	Vitamins and Related Substances	Colpidium campylum	C striatum	Colpoda duodenaria	Glaucoma scintillans	Paramecium aurelia[1]	P multimicronucleatum	Pleurotricha lanceolata	Stylonichia pustulata	Tetrahymena piriformis	Eutrichomastix colubrorum	Leishmania agamae	L. ceramodactyli	L. donovani	L. tropica	Leptomonas ctenocephali	L. pyrrhocoris	Strigomonas culicidarum[2]	S culicidarum[3]	S. fasciculata	S. mellis	S muscidarum	S. oncopelti	S parva	Trichomonas batrachorum	T columbae	T foetus	T gallinarum	T vaginalis	Trypanosoma cruzi	Acanthamoeba castellanii	Plasmodium knowlesi
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(AA)	(AB)	(AC)	(AD)	(AE)	(AF)
1	Vitamin A																															
2	Ascorbic acid			R̸						R̸	R	R̸	R̸	R	R	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R	R	R		R	R̸	
3	Biotin			R̸						R̸																						
4	Choline									R̸																						
5	Cobalamin[4]																															
6	Vitamin D																															
7	Vitamin E																															
8	Folic acid group[5]					R																										
9	Inositol			R̸						R̸																						
10	Vitamin K																															
11	Niacin[6]			R						R																						
12	Pantothenic acid			R						R																						
13	Para-aminobenzoic acid			R̸						R̸																						R
14	Pyridoxine group[7]			R						R																						
15	Riboflavine	R		R		R				R																						
16	Thiamine	R	R	R	R	R				R̸								R	R	R			R								R	
	Other growth factors																															
17	Cholesterol			R̸						R̸	R															R	R					
18	Hematin			R̸						R̸		R	R	R	R	R	R	R	R̸	R	R̸	R	R̸	R̸						R		
19	Unidentified	R		R	R	R[8]	R	R	R	R[9]	R	R		R	R	R									R	R	R	R		R		R

/1/ Var 4 Stock 51 7 (sensitive) /2/ Subspecies anophelis /3/ Subspecies culicis /4/ A generic term including cyanocobalamin (vitamin B_{12}) and it hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /5/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M, vitamin B_c, factor U L. casei factor Norite eluate factor /6/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide); also for pellagra preventive (P.P) factor antiblacktongue factor /7/ Includes pyridoxine pyridoxal, pyridoxamine /8/ Steroid of stigmasterol and sitosterol groups also brassicasterol /9/ Reported as α-lipoic acid.

18 CORRELATION OF NUTRIENT REQUIREMENTS WITH BODY WEIGHT, ENERGY METABOLISM, AND FOOD INTAKE: ANIMALS

Values are for adult forms in the resting or near-resting state and under ordinary (i.e., non-stress) environmental conditions.

	Nutrient	Requirement				
		Per kg Body Weight per day	Per kg Body Weight^0.73 per day[1]	Per sq m Body Surface per day	Per kg Food Intake[2]	Per Calorie[3]
		mg	mg	mg	mg	
	(A)	(B)	(C)	(D)	(E)	(F)
1	Vitamin A[4]	5				
2	Carotene	30				
3	Ascorbic acid	7000[5]				
4	Protein[6] digestible		1660	20 825		
5	Calcium[7]		89	575		
6	Phosphorus[8]		59	746		
7	Water					1 ml
8	Iodine					0.03-0.04 µg
9	Thiamine				1	
10	Riboflavine				1.5	
11	Pyridoxine				2	
12	Pantothenic acid				3	
13	Niacin[9,10]				10	
14	Cobalt				0.07	
15	Copper				3-5	
16	Calories[3] utilizable: basal energy expenditure		66	833		
17	Total calories[3] utilizable: very light muscular activity[11]		99[12]	1249[13]		

/1/ Metabolic "body size" /2/ Food of low fat content weighed moisture free. Values 9-15 E inclusive do not apply to the ruminant because of the synthesis of vitamins by the microorganisms of the rumen. Values 14,15 E apply to ruminants only /3/ Kilocalories /4/ Requirement for vitamin A may be satisfied by vitamin A or carotene; efficiency of conversion apparently varies with different species /5/ This value applies to guinea pigs only /6/ Assuming biological value of 50. /7/ Assuming utilization of dietary calcium of 30% /8/ Assuming utilization of dietary phosphorus of 30%. Phosphorus may also be required in proportion to the amount of dry food consumed. /9/ Nicotinic acid (niacin); nicotinic acid amide (nicotinamide) /10/ Decreases with increasing protein (tryptophan) intake /11/ Muscular activity at rate of 0.5 basal plus basal Calories: total Calories utilizable /12/ 1 33 Calories (0.5 basal) plus 66 Calories (basal) 99 total Calories utilizable/kg body weight^0.73 per day. /13/ 1 416 Calories (0.5 basal) plus 833 Calories (basal) 1249 total Calories utilizable/sq m body surface/day

19 CHEMICAL ELEMENT COMPOSITION OF NUTRIENT SOLUTIONS: HIGHER PLANTS

The nutrients listed, together with carbon supplied by CO_2 absorbed directly from the atmosphere and hydrogen derived from the water in the solution, are sufficient for satisfactory growth of most higher plant forms so far tested. Wide differences in concentration of the nutrients have been found to be permissible. The solution is renewed at intervals to avoid depletion.

	Elements[1]	Hoagland, D.R. and Arnon, D.I., 1950[2]		Robbins, W.J., 1946[3]	
		Composition of Nutrient Solutions			
		Milligram-atoms/L[4]	mg/L	Milligram-atoms/L[4]	mg/L
	(A)	(B)	(C)	(D)	(E)
1	Boron	0.046	0.5	0.009	0.1
2	Calcium	5	200	5	200
3	Chlorine[5]	0.018	0.65		
4	Copper	0.0003	0.02	0.00016	0.01
5	Iron	0.018	1.0	0.009	0.5
6	Magnesium	2	49	2	49
7	Manganese	0.009	0.5	0.0045	0.25
8	Molybdenum	0.0001	0.01	0.0001	0.01
9	Nitrogen[6] from NH_4[7]	1	14	0	0
10	Nitrogen[6] from NO_3	14	196	10	140
11	Oxygen[8]		6		6
12	Phosphorus	1	31	1	31
13	Potassium	6	235	5	195
14	Sulfur	2.05	65	4.02	129
15	Zinc	0.0008	0.05	0.0008	0.05

/1/ For compounds used in making solutions, see table 57, Composition of Nutrient Solutions: Higher Plants /2/ This solution has been found satisfactory for growth of over 40 higher plant forms tested including tomato, corn, asparagus, sequoia seedlings, etc /3/ This solution has been found satisfactory for a wide variety of higher plant species including fruit, vegetable, ornamental, field crop, silvicultural, and non-cultivated forms (citrus, tomato, rose, tobacco, spruce, etc.) /4/ Milligram-atoms per liter /5/ Not known to be essential to plant nutrition. /6/ Where environmental conditions (temperature, light) promote rapid growth, a solution high in nitrogen should be used. For light intensity over 3000 foot candles up to 550 mg total N per liter /7/ Nitrogen in the form of ammonium ion is supplied in small quantity to aid in the maintenance of favorable pH range. Ammonium ion is not otherwise needed, as such, in nutrient solutions /8/ Not included in solution formula as published, but required (in solution) for satisfactory growth. Value estimated from solubility of atmospheric oxygen in water. Must be continuously replenished by aeration when roots are constantly submerged in solution.

20 UTILIZATION OF CHEMICAL ELEMENTS CORN PLANT

Values indicate the amount of various elements used in the growth of one acre (0 4 hectare) of corn plants producing at the rate of 100 bushels per acre They represent analys s made in Illinois and Indiana during 1935-1940 Where a range is given, the lower value presents observations from corn plants grown in Indiana, the upper value, for plants grown in Illinois All other values are applicable to both localities There were approximately 12,000 plants per acre (30,000 plants per hectare) and the production of shelled corn was at the rate of 5,600 pounds per acre (6,300 kg per hectare)

Element[1]		Quantity Utilized		Element[1]		Quantity Utilized	
		lb/Acre[2]	kg/hectare			lb/Acre[2]	kg/hectare
(A)		(B)	(C)	(A)		(B)	(C)
1	Oxygen	6800	7620	9	Iron	2	2 2
2	Carbon	5200	5830	10	Manganese	0 3	0 34
3	Nitrogen	130-160	150-180	11	Boron	0 06	0 06
4	Potassium	110-125	120-140	12	Chlorine	Trace	Trace
5	Sulfur	22-75	24-84	13	Iodine	Trace	Trace
6	Magnesium	33-50	37-56	14	Zinc	Trace	Trace
7	Calcium	37-50	41-56	15	Copper	Trace	Trace
8	Phosphorus	22-40	25-45				

/1/Data for water utilized 4,300,000 to 5,500,000 pounds per acre(4,820,000 to 6,165,000 kg per hectare) /2/ Pounds per acre x 1 121 = kg per hectare

21 UTILIZATION OF NUTRIENTS LOWER ALGAE AND RELATED COLORLESS ORGANISMS

Oxygen is essential for all these organisms Carbon dioxide is required by all the species in this table for which data are available Colorless forms and green forms when grown in darkness need an additional carbon source Such additional carbon sources may stimulate growth of green forms in light under certain conditions

Utilized (U); Poorly Utilized (u); Not Utilized (U̸); Required (R); Not Required (R̸); Questionable (?)

Photosynthetic Forms

Nutrient (A)	Chlamydomonas agloeformis (B)	C moewusii (C)	Chlorogonium elongatum (D)	C euchlorum (E)	Euglena anabaena minor (F)	E deses (G)	E gracilis typica (H)	E gracilis bacillaris (I)	E gracilis urophora (J)	E klebsii[2] (K)	E pisciformis (L)	E stellata (M)	Haematococcus pluvialis (N)	Nitzschia closterium (O)
Vitamins														
1 Cobalamin[4]	R̸	R̸	R̸	R̸	R̸?		R[6]	R[6]	R[6]	R̸[5]		R̸[5]	R̸	R̸
2 Thiamine	R̸	R̸	R̸	R̸	R̸?		R[7]	R	R	R̸[5]	R[6]	R̸[5]	R̸	R̸
3 Other	R̸	R̸	R̸	R̸	R̸?					?		R̸[5]	R̸	R̸
Carbon Source Sugars														
4 Arabinose		U̸	U?	U̸?										
5 Glucose		U̸	U̸?	U̸?	U̸	U̸	U̸	U	U̸	U̸	U̸			
6 Maltose		U̸	U̸?	U̸?										
7 Sucrose		U̸	U?	U̸?	U̸	U̸	U̸			U̸	U̸			
8 Xylose		U̸	U̸?	U̸?										
Carbon Source: Organic Acids (Other Than Fatty Acids)[10]														
9 Citric	U̸	U̸			U̸	U̸	U̸	U̸	U̸	U̸			U̸	
10 Fumaric		U̸						U	U					
11 Lactic	U̸	U̸		U̸	U̸		U	U̸	U			U̸	U̸	
12 Malic	U̸	U̸		U̸	U̸	U̸	U	U	U	U̸	U̸		U̸	
13 Phosphoglyceric	U̸	U̸			U̸	U̸	U̸	U			U̸		U̸	
14 Pyruvic		U̸		u	U̸	U̸	U		U		U̸	U̸		
15 Succinic	U̸	U̸		U	U̸	U̸	U	U	U̸?		U̸		U̸	
Carbon Source Alcohols[12]														
16 i-Butanol							U̸		U					
17 n-Butanol		U̸					U		U					
18 Ethanol		U̸	U̸	U̸		U	U		U					
19 Glycerol		U̸			U̸	U̸					U̸	U̸		
20 n-Hexanol							U		U					
21 Methanol							U̸		U̸					
22 i-Pentanol							U̸		U̸					
23 n-Pentanol							U̸		U̸					
24 i-Propanol							U̸		U̸					
25 n-Propanol							U		U					
Carbon Source Fatty Acids[14]														
26 Acetic	U	U̸	U	U	U̸	U̸	U	U	U	U̸	U̸	U̸	U	

Colorless Forms

Nutrient (A)	Astasia longa[3] (P)	A quartana (Q)	Chilomonas paramecium (R)	Hyalogonium klebsii (S)	Polytoma caudatum (T)	P obtusum (U)	P ocellatum (V)	P uvella (W)	Polytomella caeca (X)	Prototheca zopfii (Y)
Vitamins										
1 Cobalamin[4]	R		R̸							
2 Thiamine	R		R[8]		R[9]	R̸	R[9]	R̸	R[8]	R[8]
3 Other	R̸		R̸			R̸		R̸		
Carbon Source Sugars										
4 Arabinose			U̸?					U̸		U̸
5 Glucose	U̸		U̸?				U̸	U̸	U̸	U
6 Maltose			U̸?						U̸	U̸
7 Sucrose			U̸?						U̸	U̸
8 Xylose			U̸?					U̸		U̸
Carbon Source: Organic Acids (Other Than Fatty Acids)[10]										
9 Citric						U̸				U̸
10 Fumaric										U̸
11 Lactic	U?	U	U	U̸	U̸	U̸	U	U?	U̸?	U[11]
12 Malic	U?	U̸	U̸	U̸		U̸	U̸?	U̸	U̸	
13 Phosphoglyceric						U̸				
14 Pyruvic	U̸?		U	U̸	U		U		u	U[11]
15 Succinic	U?	U		U		U̸	U̸?	U?	u	U̸
Carbon Source Alcohols[12]										
16 i-Butanol			U̸		U̸	U̸	U	U̸	U	U
17 n-Butanol	U	U̸	U		U̸	U̸	U	U̸	U	U
18 Ethanol	U	U̸	U	U̸	U̸	U̸	U	U̸	U	U
19 Glycerol										U
20 n-Hexanol	U	U̸	U				U		U	
21 Methanol	U̸	U̸	U̸		U̸	U̸	U̸	U̸	U̸	U̸
22 i-Pentanol	U̸		U̸				U̸		U̸	u
23 n-Pentanol	U̸		u[13]		U̸	U̸		U̸	U̸	U
24 i-Propanol	U̸		U̸		U̸		U̸	U̸	U̸	U̸
25 n-Propanol	U	U̸	u[13]		U̸	U̸	U	U̸	U	U
Carbon Source Fatty Acids[14]										
26 Acetic	U	U	U	U	U	U	U	U	U	U

/1/ According to E. G. Pringsheim the organism used in these studies was E. gracilentata /2/ According to E. G. Pringsheim, the organism used in these studies was E. mutabilis /3/ Syn. A. chattoni (A. Lwoff 1956) or A. klebsii (E. von Dach 1940) /4/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /5/ It has been reported that the organism requires no vitamins, but it is possible that this comes about only after adaptation to vitamin-less media as with other species of Euglena. /6/ The organism utilizes also pseudo-cobalamin. /7/ Can be replaced by pyrimidine /8/ Can be replaced by pyrimidine and thiazole /9/ Can be replaced by thiazole /10/ Negative results reported for organic acids may not be significant since it has been shown that Prototheca zopfii and Euglena gracilis utilize them only at pH 3 5-3 5. Most of the negative results tabulated were obtained in media having pH near neutrality /11/ Utilized only at pH 3 0-3 5 /12/ Optimal concentrations are similar to those of the corresponding fatty acid (cf Fn 14) /13/ Inadequate for growth in mineral medium. /14/ The average range of concentration in grams per 100 ml of media at which fatty acids are utilized and non-toxic is the following: acetic propionic butyric and isobutyric acids 0 1-0.8; valeric and isovaleric acids 0 05-0 1; caproic isocaproic heptylic and octylic acids 0 01-0 05; nonylic acid 0 01 decylic acid, 0 005-0 006. Some of the negative results tabulated may be incorrect if toxic concentrations were employed. In general toxicity increases with the length of the chain of carbon atoms and with the decrease in the pH of the medium.

21 UTILIZATION OF NUTRIENTS LOWER ALGAE AND RELATED COLORLESS ORGANISMS (Concluded)

Oxygen is essential for all these organisms. Carbon dioxide is required by all the species in this table for which data are available. Colorless forms and green forms when grown in darkness need an additional carbon source. Such additional carbon sources may stimulate growth of green forms in light under certain conditions.

Utilized (U); Poorly Utilized ( ); Not Utilized (Ø); Required (R); Not Required (R̸); Questionable (?)

	Organism / Nutrient	Photosynthetic Forms: Chlamydomonas agloeformis	C. moewusii	Chlorogonium elongatum	C. euchlorum	Euglena anabaena minor	E. deses[1]	E. gracilis typica	E. gracilis bacillaris	E. gracilis urophora	E. klebsii[2]	E. pisciformis	E. stellata	Haematococcus pluvialis	Nitzschia closterium	Colorless Forms: Astasia longa[3]	A. quartana	Chilomonas paramecium	Hyalogonium klebsii	Polytoma caudatum	P. obtusum	P. ocellatum	P. uvella	Polytomella caeca	Prototheca zopfii
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)
	Carbon Source Fatty Acids[14] (Concluded)																								
27	i-Butyric	Ø		Ø	Ø	Ø	Ø	Ø		U		Ø		Ø			u	Ø	Ø	Ø	Ø	U	Ø	Ø	U
28	n-Butyric	U	Ø	U	Ø	Ø	Ø	U	U	U	Ø	Ø		U		U	U	U	Ø	U	U	U	U	U	U
29	i-Caproic									u						u	U	U		Ø	Ø	U	U		U
30	n-Caproic	Ø		Ø	Ø	Ø	Ø15	U		U		Ø15		Ø		U	U	U	Ø	Ø	Ø	U	U	U	U
31	n-Decylic							U												Ø	Ø	U	Ø	U	U
32	n-Heptylic					Ø17	Ø15	Ø		U		Ø15				U	U			Ø	Ø	U	Ø	U	U
33	n-Nonylic					Ø15	Ø15	U				Ø15				U				Ø	Ø	U	Ø	U	U
34	n-Octylic					Ø15	Ø15	U		U		Ø15				U		U		Ø	Ø	U		U	U
35	Propionic	Ø	Ø	Ø	Ø	Ø	Ø	U		U	Ø	Ø	Ø	Ø		U	U	Ø	Ø	Ø	Ø	U	Ø	U	U
36	i-Valeric					Ø	Ø	Ø		Ø		Ø				Ø		u		Ø	Ø		Ø	Ø	u
37	n-Valeric	Ø	Ø	Ø	Ø	Ø	Ø	U		U		Ø		Ø		U	U	U	Ø	Ø	Ø	U	U	U	U
	Nitrogen Sources[16]																								
38	D-Alanine					U	U	U17	U17		U	Ø18	U									U	Ø		
39	Ammonium	U	U	U	U	U	Ø	U17	Ø17	U17	u	U18	U	U	U	U		U		U	U	U	U	U	U
40	D-Arginine					Ø	Ø	Ø			Ø	Ø18	U												
41	L-Asparagine	U17	U		U17	U	U	U17			U	U19	U	U17						U	U		U		
42	D-Glutamic Acid[20]					Ø	U	U17	U17	U17 U17	U	Ø18	U		U										
43	Glycine	U17				U	Ø	U17			U	Ø18	U	U17							U		U		
44	Histidine					Ø	Ø	U17			U	Ø18	U										u		
45	L-Leucine					U	U	U17			U	Ø18	U								u		Ø		
46	D-Lysine					Ø	U	Ø			U	Ø18	U												
47	Nitrate	U	U	U	U	U	Ø	u	Ø	Ø		Ø18	U	u	U			?		Ø	Ø	U	Ø	Ø	
48	Peptone	U17	U	U17	U17	U	U	U17	U17	U17	U	U	U	U17	U	U	U	U	U	U	U	U	U	U	U
49	DL-Phenylalanine					U	Ø	U17			Ø	Ø18	U								u				
50	DL-Proline					U	U	U17			U	Ø18	U												
51	DL-Serine					Ø		U17			U	Ø18	U								u		u		
52	L-Tryptophan					Ø	Ø	Ø			Ø	Ø18	Ø								u				
53	L-Tyrosine					Ø	Ø	Ø			Ø	Ø18	Ø												
54	DL-Valine					U	Ø	U17			U	Ø18	U										u		

/1/ According to E. G. Pringsheim, the organism used in these studies was E. geniculata. /2/ According to E. G. Pringsheim the organism used in these studies was E. mutabilis. /3/ Syn. A. chattoni (A. Lwoff 1936) or A. klebsii (E. von Dach 1940). /14/ The average range of concentration in mg per 100 ml of media at which fatty acids are utilized and non-toxic is the following: acetic, propionic, butyric, and isobutyric acids 0.1-0.2; valeric and isovaleric acids 0.05-0.1; caproic, isocaproic, heptylic, and octylic acids 0.01-0.03; nonylic acid, 0.01; decylic acid 0.005-0.008. Some of the negative results tabulated may be incorrect if toxic concentrations were employed. In general, toxicity increases with the length of the chain of carbon atoms and with the decrease in the pH of the medium. /15/ Acid employed at toxic concentrations. /16/ Colorless forms utilize the same nitrogen sources in light as in darkness. For photosynthetic forms, data pertain to utilization in light; the same nitrogen sources which are utilized in darkness are indicated by Fn 17. Some of the amino acids listed may, where utilized, also serve as carbon source for some organisms. /17/ Also utilized in darkness. /18/ Negative results may not be valid because tests were conducted in medium lacking thiamine. /19/ Growth [illegible] obtained only if thiamine is present. /20/ When utilized, it is a good carbon source.

22 AMINO ACID REQUIREMENTS BACTERIA

Required (R); Not Required (R̸)

Amino Acid / Organism	Aerobacter aerogenes	Bacillus alvei	B anthracis	B brevis	B cereus	B cereus var mycoides	B circulans	B coagulans	B licheniformis	B macerans	B megaterium	B pasteurii	B polymyxa	B pumilus	B sphaericus	B subtilis	B subtilis var niger	Brucella abortus	B melitensis
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
1 Alanine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
2 Arginine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
3 Aspartic acid	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
4 Citrulline	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
5 Cystine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
6 Glutamic acid	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
7 Glycine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
8 Histidine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
9 Hydroxyproline	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
10 Isoleucine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
11 Leucine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
12 Lysine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
13 Methionine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
14 Norleucine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
15 Proline	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
16 Serine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
17 Threonine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
18 Tryptophan	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
19 Tyrosine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
20 Valine	R̸								R̸	R̸	R̸		R̸	R̸		R̸	R̸		
21 Amino acids unspecified		R	R	R	R	R	R	R				R			R			R[1]	R[1]
22 Other Nitrogen source	R̸								R[2]	R[2]	R[2]	R[2]	R[2]	R[2]		R[2]	R[2]		

/1/ Certain strains; other strains have no known requirement /2/ As NH_3; varies in case of B pasteurii

22 AMINO ACID REQUIREMENTS BACTERIA

Required (R); Not Required (N)

	Amino acid / Organism (A)	Brucella suis (U)	Erwinia amylovora (V)	E spp[3] (W)	E tracheiphila (X)	Escherichia coli (Y)	Lactobacillus arabinosus 17 5 (Z)	L (hetero-fermentative) (BB)	Leuconostoc citrovorum (CC)	L dextranicum (DD)	L mesenteroides (EE)	Pasteurella multocida (FF)	P pestis (GG)	P tularensis (HH)	Proteus morgani (II)	Salmonella cholerae-suis[4] (JJ)	S typhosa (KK)	Serratia marcescens (LL)	Shigella paradysenteriae (MM)	S sonnei (NN)
1	Alanine	N	N	N	N	N	N				R							N		N
2	Arginine	N	N	N	N	N	R				R							N		N
3	Aspartic acid						N				R									
4	Citrulline	N	N	N	N	N	N				N							N		N
5	Cystine	N	N	N	N	N	R				R			R	R			N		N
6	Glutamic acid	N	N	N	N	N	R				R							N		N
7	Glycine	N	N	N	N	N	N				R							N		N
8	Histidine	N	N	N	N	N	N				R							N		N
9	Hydroxyproline	N	N	N	N	N	N				N							N		N
10	Isoleucine	N	N	N	N	N	R				R							N		N
11	Leucine	N	N	N	N	N	R				R							N		N
12	Lysine	N	N	N	N	N	R?				R							N		N
13	Methionine	N	N	N	N	N	R				R							N		N
14	Norleucine	N	N	N	N	N	N				N							N		N
15	Proline	N	N	N	N	N	N				R							N		N
16	Serine	N	N	N	N	N	N				R							N		N
17	Threonine	N	N	N	N	N	R				R							N		N
18	Tryptophan	N	N	N	N	N	R		R	R	R						R[1]	N		N
19	Tyrosine	N	N	N	N	N	R				R					R[5]		N		N
20	Valine	N	N	N	N	N	R				R							N		N
21	Amino acids unspecified	R[1]					R[6]	R[6]	R[7]	R[7]	R[7]	R	R[8]	R		R[5]	R		R[6]	R[6]
22	Other Nitrogen source		R[2]	R[2]	R[2]	R[2]												R[2]		R[2]

/1/ Certain strains; other strains have no known requirement /2/ As NH_3 /3/ Various species of soft rot group /4/ Ammonium sulfate or aspara ine usually suffice but ty sine or other amino acids occasionall required /5/ Applies also to S enteritidis S gallinarum,

23 UTILIZATION OF SUGARS FOR GROWTH FILAMENTOUS FUNGI

Interpretation of the amount of growth obtained on different sugars is often subject to error. Low yields may be due to slow utilization of the sugar involved but are frequently due to other factors. It is possible that some organisms listed as not utilizing (Ø) a certain sugar or utilizing it poorly (u) will be found to utilize it well (U) under different nutritional conditions.

Utilized (U); Utilized slowly (u); Utilization slight or none (Ø)

	Species / Sugar	D-Glucose	D-Fructose	D-Mannose	D-Galactose	L-Sorbose	L-Arabinose	D-Xylose	Maltose	Sucrose	Lactose	Cellobiose	Raffinose
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
1	Achlya flagellata	U	Ø	Ø	Ø		Ø	Ø	U	U	Ø		Ø
2	Alternaria solani	U	U	U	U	u	U	U	U	U	u	u	u
3	Aspergillus clavatus	U	U	U	U	Ø	U	U	U	U	u	U	U
4	A. elegans	U	U	U	u	u	U	U	U	U	u	u	U
5	A. niger	U	U	U	u	U	u	U	U	U	u		
6	A. oryzae	U	U	U	U		u	u	U		Ø		u
7	A. rugulosus	U	U	U	U	u	U	U	U	U	u	u	U
8	Blakeslea trispora	U	U	U	U				U	u	u		
9	Blastocladia pringsheimii	U	U	U	Ø	Ø	Ø	Ø	U	U	Ø		
10	Botrytis cinerea	U	U	U	U	U	U	U	U	U	U	U	U
11	Ceratostomella fimbriata	U	u	U	u	Ø	u	u	U	U	Ø	u	Ø
12	Chaetomium convolutum	U	u	U	U	Ø	U	U	U	U	u	U	Ø
13	C. globosum	U	U	U	U	u	u	u	U	U	u	u	u
14	Choanephora cucurbitarum	U	U	U	U	Ø	u	u	U	Ø	Ø	U	Ø
15	Coccidioides immitis	U	U	U	U		Ø	u	U	Ø	Ø	U	u
16	Colletotrichum lindemuthianum	U	U	U	U	Ø	u	u	U	U	U	U	U
17	Collybia velutipes	U	U	U	u	Ø	u	u	U	U	u	U	u
18	Cordyceps militaris	U	U	U	U	Ø	u	U	U	u	Ø	U	u
19	Dendrophoma obscurans	U			u	Ø			U	U	Ø		
20	Diaporthe phaseolorum batat	U	U						U	U	U		
21	Dictyuchus monosporus	U	Ø	Ø	Ø		Ø	Ø	Ø	Ø	Ø		Ø
22	Diplodia macrospora	U	U	U	U				U	U	u		
23	D. natalensis	U	U	U	u				U	U	u		
24	Endoconidiophora fagacearum[1]	U	u	U	u	Ø	u	u	u	U	Ø	U	u
25	Endothia parasitica	U	U	U	u	u	u	u	U	U	Ø	U	U
26	Entomophthora apiculata	U	u	U	u	u	Ø	Ø	Ø	Ø	Ø	Ø	Ø
27	E. coronata	U	U	U	u	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
28	Fusarium conglutinans	U	U	U	U	u	U	U	U	U	u	u	u
29	F. culmorum	U	U	U	U	u	u	u	u	u	u	U	U
30	F. lycopersici	U	U	U	U	U	U	U	U	U	u	u	u
31	F. medicaginis	U	U	U	U	u	U	U	U	U	u	u	U
32	F. nivale	U	U	U	U	u	U	U	U	U	u	U	U
33	F. niveum	U	U	U	U	U	U	U	U	U	U	U	U
34	F. tracheiphilum	U	U	U	U	u	U	U	U	u	U	u	U
35	Glomerella cingulata	U	U	U	U	u	U	U	U	U	u	U	U
36	Helicostylum pyriforme	U	U	U	U				U	u	u		
37	Helminthosporium sativum	U	U	U	u	u	u	u	U	U	u	u	u
38	Lenzites sepiaria	U	U	U	u	u	Ø	u	U	u	u	Ø	Ø
39	L. trabea	U	u	U	u	u	u	u	U	u	U	U	u
40	Leptomitus lacteus	Ø	Ø		Ø				Ø	Ø			

/1/ Formerly Chalara quercina.

23 UTILIZATION OF SUGARS FOR GROWTH FILAMENTOUS FUNGI (Concluded)

Interpretation of the amount of growth obtained on different sugars is often subject to error. Low yields may be due to slow utilization of the sugar involved but are frequently due to other factors. *It is possible that some organisms listed as not utilizing (∅) a certain sugar, or utilizing it poorly (u) will be found to utilize it well (U) under different nutritional conditions.*

Utilized (U); Utilized slowly (u); Utilization slight or none (∅)

	Species / Sugar	D-Glucose	D-Fructose	D-Mannose	D-Galactose	L-Sorbose	L-Arabinose	D-Xylose	Maltose	Sucrose	Lactose	Cellobiose	Raffinose
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
41	Melanconium fuligineum	U	U	U	U	u	u	u	U	U	∅	U	u
42	Memnoniella echinata	U	U	U	U		U	U	U	U	U	U	U
43	Monilinia fructosa	U	U	U	U	U	u	U	U	U	∅	U	u
44	Monosporium apiospermum	U	U	U	U	∅	u	U	u	U	u	u	u
45	Mucor ramannianus	U	U	U	U	u	u	U	U	∅	U	U	∅
46	Neocosmospora vasinfecta	U	U	U	U	∅	U	U	U	U	u	u	u
47	Ophiobolus graminis	U	u	U	U	∅	u	u	U	U	u	u	u
48	Penicillium chrysogenum	U	U	U	U	u	U	U	U	U	u	u	U
49	P. digitatum	U	U	U	U		U	U	u	U	U	U	
50	P. expansum	U	U	U	U	u	u	U	U	U	∅	U	U
51	P. spiculosporum	U	U	U	U	u	U	U	U	U	∅	U	u
52	Phoma betae	U	U	U	U	u	U	U	U	U	u	U	U
53	Phycomyces blakesleeanus	U	U	U	u	∅	u	U	U	U	∅	u	∅
54	Phymatotrichum omnivorum	U	U	U	∅			∅	U	U	u		u
55	Phytophthora cactorum	U	u	u	∅				U	U	∅		
56	P. erythroseptica	U	u	U	∅				U	U	∅		
57	P. fagopyri	U	u	u	∅				u	U	∅		
58	P. infestans	U	U	u	∅	∅	∅	∅	u	u	∅	∅	∅
59	Pilaira moreaui	U	U	U	U				U	u	U		
60	Polyporus albellus	U	u	U	u	∅	u	U	U	∅	∅	u	∅
61	P. versicolor	U	U	U	u	u	U	u	U	U	u	U	u
62	Pythiogeton uniforme	U	U		∅		∅	U	U	U	u	U	
63	Pythiomorpha gonapodyoides	U	U	u	∅				u	U	∅		
64	Pythium ascophallon	U	u	U	∅				U	U	∅		
65	Rhizophlyctis rosea	U	∅	∅	∅	∅	∅	∅	∅	∅	∅	U	
66	Rhizopus nigricans	U	U	U	U				U	∅	∅		
67	R. suinus	U	U	U	U				u	∅	∅		
68	Rosellinia arcuata	U	U	U	u				U	u	u		
69	Saprolegnia delica	U	U	∅	∅		∅	∅	U	∅	∅		∅
70	S. ferax	U	∅	∅	∅		∅	∅	U	∅	∅		∅
71	Schizophyllum commune	U	U	U	u	∅	u	u	u	u	u	u	u
72	Schizothecium longicolle	U	U	U	∅	∅	∅	U	U	∅	∅	U	∅
73	Sclerotium delphinii	U	U				U	U	U	U			
74	Septoria nodorum	U			u	∅			u	u	u		
75	Sordaria fimicola	U	U	U	u	∅	u	u	U	u	u	U	∅
76	Sphaeropsis malorum	U	U	U	U	u	u	u	U	U	u	U	u
77	Stysanus stemonitis	U	u	U	U	∅	U	u	U	U	U	U	U
78	Syncephalastrum racemosum	U	U	U	U	∅	u	u	U	∅	∅	u	u
79	Thielavia basicola	U	U	U	U				U	U	∅		
80	Thraustotheca clavata	U	∅	∅	∅		∅	∅	U	U	∅		∅
81	Typhula variabilis	U	U	U	u				U	U	∅		
82	Ustilago violacea	U	U	U	U		∅	∅	U	U	∅	U	∅

Utilized (U); Not Utilized (Ʉ); Variable (u)

Carbohydrates and related substances / Yeast	Candida albicans	C guilliermondii	C krusei	C lipolytica	C parapsilosis	C pulcherrima	Debaryomyces globosus[1]	Hansenula anomala	H. californica	H. canadensis	H. capsulata	H. jadinii	H. mrakii	H. saturnus	H. silvicola	H. suaveolens
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
1 D-Arabinose	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	u	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
2 L-Arabinose	u	U	Ʉ	Ʉ	U	Ʉ	Ʉ	u	Ʉ	Ʉ	U	Ʉ	Ʉ	Ʉ	U	Ʉ
3 Cellobiose	Ʉ	U	Ʉ	Ʉ	Ʉ	U	Ʉ	U	U	U	U	U	U	U	U	U
4 Dulcitol	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
5 i-Erythritol	Ʉ	Ʉ	Ʉ	U	Ʉ	Ʉ	Ʉ	U	Ʉ	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
6 Ethyl alcohol	Ʉ	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
7 Galactose	U	U	Ʉ	u	U	U	Ʉ	u	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	U	Ʉ
8 Glucose	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
9 Glycerol	u	U	U	U	U	U	u	U	U	U	U	U	U	U	U	U
10 Inulin	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	u	Ʉ	Ʉ	Ʉ	Ʉ	U	Ʉ	U	Ʉ	U
11 Lactose	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	u	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
12 Maltose	U	U	Ʉ	Ʉ	U	U	Ʉ	U	u	U	U	U	Ʉ	Ʉ	U	Ʉ
13 D-Mannitol	U	U	Ʉ	U	U	U	U	U	U	U	U	U	U	u	u	U
14 Melezitose	U	U	Ʉ	Ʉ	U	U	Ʉ	U	Ʉ	U	U	U	Ʉ	Ʉ	u	Ʉ
15 Melibiose	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
16 Raffinose	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	U	U	Ʉ	Ʉ	Ʉ	U	Ʉ	U	Ʉ	U
17 L-Rhamnose	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	U	U	U	Ʉ	U	U	U	Ʉ
18 D-Ribose	u	U	Ʉ	u	U	U	Ʉ	u	Ʉ	Ʉ	U	Ʉ	Ʉ	Ʉ	U	Ʉ
19 D-Sorbitol	U	U	Ʉ	U	U	U	Ʉ	U	U	U	U	U	U	u	U	U
20 L-Sorbose	u	U	Ʉ	u	U	U	Ʉ	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	U	Ʉ
21 Starch, soluble	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	U	Ʉ	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
22 Sucrose	U	U	Ʉ	Ʉ	U	U	U	U	U	U	Ʉ	U	Ʉ	U	U	U
23 Trehalose	U	U	Ʉ	Ʉ	U	U	u	U	u	U	U	U	Ʉ	Ʉ	U	Ʉ
24 D-Xylose	U	U	Ʉ	Ʉ	U	U	Ʉ	u	U	U	U	U	U	U	U	U
25 Citrate	U	U	u	U	U	u	Ʉ	U	u	U	Ʉ	U	Ʉ	u	U	Ʉ
26 Potassium D-gluconate	u	U	Ʉ	U	U	U	u	u	U	U	u	U	U	U	U	U
27 Calcium 2 keto-D-gluconate	U	U	Ʉ	Ʉ	U	U	U	Ʉ	u	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
28 Potassium 5-keto-D-gluconate	U	u	Ʉ	Ʉ	U	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
29 α-Methyl-D-glucoside	u	U	Ʉ	Ʉ	U	U	Ʉ	U	U	U	u	U	Ʉ	Ʉ	U	Ʉ
30 i Inositol	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
31 DL-Lactate	U	u	U	U	Ʉ	u	u	U	U	U	Ʉ	U	U	U	u	U
32 Pyruvate	U	U	U	U	U	u	u	U	U	U	u	U	U	U	U	U
33 Potassium sodium saccharate	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ	Ʉ
34 Salicin	Ʉ	U	Ʉ	u	Ʉ	U	Ʉ	U	U	U	U	U	U	U	U	U
35 Succinate	U	U	U	U	U	U	Ʉ	U	U	U	Ʉ	U	U	U	U	U

/1/ Saccharomyces rosei

24 UTILIZATION OF CARBOHYDRATES YEASTS (Concluded)

Utilized (U); Not Utilized (Ø); Variable (u)

	Carbohydrates and related substances \ Yeast	Hansenula subpelliculosa	Kloeckera brevis[2]	Nadsonia fulvescens	Nematospora coryli	Pichia alcoholophila[3]	Rhodotorula gracilis[4]	R. minuta	Saccharomyces bayanus	S. marxianus	Saccharomycodes ludwigii	Schizosaccharomyces octosporus	Torulaspora rosei[1]	Torulopsis bacillaris	T. utilis[5]	Trichosporon capitatum	Zygosaccharomyces fermentati[6]	Z. pastori[7]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
1	D-Arabinose	Ø	Ø	Ø	Ø	Ø	U	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
2	L-Arabinose	u	Ø	Ø	Ø	Ø	U	U	U	U	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø
3	Cellobiose	u	U	Ø	Ø	Ø	U	U	Ø	U	Ø	Ø	Ø	Ø	U	Ø	U	Ø
4	Dulcitol	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
5	i Erythritol	U	Ø	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
6	Ethyl alcohol	U	Ø	U	U	U	U	U	U[8]	U	U	u	U	Ø	U	U	u	U[8]
7	Galactose	u	Ø	Ø[9]	Ø	Ø	U	U	Ø	U	Ø	Ø	Ø	Ø	Ø	U	U	Ø
8	Glucose	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
9	Glycerol	U	Ø	U	U	U	U	U	U	U	u	Ø	U	Ø	U	U	u	U
10	Inulin	Ø	Ø	Ø	Ø	Ø	u	Ø	Ø	U	Ø	Ø	U	Ø	u	Ø	U	Ø
11	Lactose	Ø	Ø	Ø	Ø	Ø	Ø	U[8]	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
12	Maltose	U	Ø	Ø[9]	U	Ø	U	Ø	U	Ø	Ø	U	u	Ø	U	Ø	U	Ø
13	D-Mannitol	U	Ø	Ø	Ø	Ø	U	u	U	U	Ø	Ø	U	Ø	u	Ø	U	U
14	Melezitose	u	Ø	Ø	Ø	Ø	U	U	Ø	Ø	Ø	Ø	Ø	Ø	U	Ø	U	Ø
15	Melibiose	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
16	Raffinose	U	Ø	Ø	U	Ø	U	U	U	U	U	Ø	U	U	U	Ø	U	Ø
17	L-Rhamnose	Ø	Ø	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	U
18	D-Ribose	u	Ø	Ø	Ø	Ø	U	U	Ø	u	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
19	D-Sorbitol	U	Ø	u	Ø	Ø	U	u	Ø	U	Ø	Ø	U	Ø	u	Ø	U	U
20	L-Sorbose	Ø	Ø	U	Ø	U	Ø	U	Ø	Ø	Ø	Ø	U	Ø	Ø	U	U	Ø
21	Starch soluble	u	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
22	Sucrose	U	Ø	Ø[9]	U	Ø	U	U	U	U	U	Ø	U	U	U	Ø	U	Ø
23	Trehalose	U	Ø	Ø	U	Ø	U	U	U	u	Ø	Ø	U	Ø	U	Ø	U	U
24	D-Xylose	u	Ø	Ø	Ø	Ø	U	U	Ø	U	Ø	Ø	Ø	Ø	U	Ø	u	Ø
25	Citrate	U	Ø	Ø	Ø	Ø	U	Ø	Ø	u	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø
26	Potassium D-gluconate	U	U	U	Ø	Ø	U	U	Ø	Ø	Ø	Ø	U	Ø	U	Ø	u	Ø
27	Calcium 2 keto-D-gluconate	Ø	U	Ø	Ø	Ø	U	U	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø	U	Ø
28	Potassium 5-keto-D-gluconate	Ø	Ø	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
29	α-Methyl-D-glucoside	U	Ø	Ø	Ø	Ø	Ø	U	U	Ø	Ø	Ø	u	Ø	u	Ø	U	Ø
30	i-Inositol	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
31	DL-Lactate	U	Ø	Ø	Ø	u	U	u	U	U	Ø	Ø	U	Ø	U	U	u	U
32	Pyruvate	U	Ø	Ø	Ø	u	U	U	U	U	Ø	Ø	U	Ø	U	U	u	U
33	Potassium sodium saccharate	Ø	Ø	Ø	Ø	Ø	Ø	u	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
34	Salicin	U	U	Ø	Ø	Ø	U	U	Ø	U	u	Ø	Ø	Ø	U	U	U	Ø
35	Succinate	U	Ø	U	U	u	U	U	Ø	U	Ø	Ø	Ø	Ø	U	U	U	U

/1/ Saccharomyces rosei /2/ K. apiculata /3/ P membranaefaciens /4/ R glutinis /5/ Candida utilis /6/ Saccharomyces fermentati /7/ Saccharomyces pastori /8/ Also reported not utilized /9/ Also reported utilized.

Data are applicable to vitamins which must be supplied each organism in its substrate. In each case the organism synthesizes all other vitamins needed in its metabolism. 0 denotes that the organism synthesizes all the vitamins it requires. Certain species not listed in this table require growth substrates of yet unidentified nature which may be supplied by the addition of yeast extract or other complex organic materials. Different isolates of the same species may have different vitamin requirements.

Biotin (B); Inositol (I); Niacin (N); Pantothenic acid (Pan); Para-aminobenzoic acid (Pab); Pyridoxine (Pyr); Thiamine (T); None (0);

Species A	Vitamins Required in Substrate B
Absidia ramosa	T[1]
Absidia spp.[2]	0
Acanthorhynchus vaccinii	T or B
Achlya conspicua	0
Achorion spp.[3]	0
Acremoniella lutzi	0
Acremonium potronii	T
Allescheria boydii	B
Allomyces arbuscula	T[4]
Alternaria solani	0
Amanita pantherina	T[5]
Aphanomyces camptostylus	0
A. phycophilus	T
Armillaria mellea	0
Ascobolus spp.[6]	0
Ascochyta pisi	0
Ascoidea rubescens	Pyr
	T
Ashbya gossypii	B
	I
	T
Aspergillus spp.[7]	0
Basidiobolus ranarum	0
Basisporium gallarum	0
Blakeslea trispora	T[1]
[illegible] pringsheimii	B
	N
	T
[illegible] brasiliensis	T
[illegible]tidis	0
B.	T[9]
lutea	0
Botryotinia convoluta	T[10]
Botrytis allii and cinerea	0
Brettanomyces bruxellensis	Pyr
Bulgaria inquinans	T
Calocera viscosa	T
Candida chevalieri	0
tropicalis	B

Species A	Vitamins Required in Substrate B
C. pseudotropicalis (cont'd)	N
	Pan
	T
C. [illegible]	T
6 C. spp.[11]	B
7 C. spp.[12]	B
	T
8 Catenularia sp.	0
9 Cenococcum graniforme	B[10]
	T[1]
0 Cephalosporium [illegible]	0
1 Cephalothecium roseum	0
Ceratostomella adiposum	I
3 C. leptographioides	B[10]
4 C. rostrocylindrica	0
5 C. stenoceras	T
6 Ceratostomella spp.[13,14]	B[9]
	Pyr[9]
	T
7 Ceratostomella spp.[15]	Pyr[9]
	T[10]
8 C. obscura and radicicola	B
	T
Cercospora apii and beticola	0
Chaetocladium brefeldii and macrosporum	T
Chaetomium convolutum	B
	T
Chaetomium spp.[16]	0
3 Chaetostylum fresenii	0
Chalara quercina[17]	B[10]
	T[10]
Chalaropsis thielavioides	T
Choanephora cucurbitarum	T
7 Ciboria acerina[17]	0
C. acerina[17]	T[10]
C. acerina[17]	B[10]
	T
C. pseudotuberosa	T[10]

Species A	Vitamins Required in Substrate B
Ciboria erythronii	0
Circinella aspera and spinosa	0
Cladosporium herbarum and werneckii	0
Clavaria ligula	T
Clitocybe spp.[18]	T
Clitopilus prunulus	T[5]
Coemansia interrupta	B
	T
Colletotrichum circinans	0
C. lindemuthianum[17]	0
C. lindemuthianum[17]	T[10]
Collybia spp.[19]	T
C. dryophila	B
	T
C. velutipes	B[20]
	T[21]
Coprinus spp.[7]	T[22]
Cordyceps militaris	0
Corticium vagum	T
Cortinellus bulbiger	T
Coryne sarcoides	B
	T
Cryptococcus sp.	T
Cudonia circinans	T
Cunninghamella spp.[23]	0
Cyathus striatus	T
Cytospora sp.	T
Dacryomyces stillatus	T
Daedalea spp.[24]	T
Daldinia concentrica	0
Dasyobolus immersus	T
Debaryomyces membranaefaciens	B
	T
Debaryomyces spp.[25]	B
Dematium [illegible]	T
Dematium chodati and pullulans	0
D. nigrum	T

Species A	Vitamins Required in Substrate B
9 Dendrophoma obscurans	T
9 Dermatea balsamea	T
9 Diaporthe trunella	0
Dichotomophora fulv	T
9 Diplodia macrospora	B
9 Dipodascus uninucleatus	B
	T
Dothidella quercus	0
Endodermophyton concentricum and tropicale	0
0 Endothia parasitica	B
	T
0 Entyloma arnoseridis	0
0 Epichloe typhina	I[10]
	T
Epidermophyton floccosum	0
0 Eremascus fertilis	0
Eremothecium ashbyi	B
	I
	T
0 Exobasidium vaccinii	T
Flammula carbonaria and penetrans	T
Fomes spp.[26]	T
1 F. fraxineus	0
Fusarium [illegible][27]	B
1 Fusarium spp.[28]	0
1 Ganoderma lucidum	T
Glenosporella loboi	0
Glenosporopsis amazonica	T
Gliocladium fimbriatum	0
Gloeocystidium roseocremeum	T
1 Glomerella cingulata	0
1 Grosmannia serpens	B
Gymnoascus setosus	0
? Hansenula anomala	0
? H. subpelliculosa	T
? H. suaveolens	B
Haplosporangium parvum	0

25 ESSENTIAL ORGANIC COMPOUNDS (VITAMINS) REQUIREMENTS: FUNGI (Continued)

125	Helminthosporium spp.[29]	O	143	Lambertella corni-maris	B[10] T	160	Merulius lacrymans	T	[illegible]	Nematospora coryli	O
126	Helvella infula	T	144	Lambertella spp.[32]	B[10] T	[illegible]	Microsporum audouini	B Pyr	[illegible]	N. gossypii	B I T
127	Hemispora stellata	O	145	Lentinus omphalodes	T	[illegible]	Microsporum spp.[37]	O	[illegible]	Neocosmospora vasinfecta	O
128	Histoplasma capsulatum	O	146	L. tigrinus	T[33]	[illegible]	Monascus purpureus	O	[illegible]	Neurospora spp.	B
129	H. capsulatum[27]	B	147	Lenzites spp.[34]	T[10]	[illegible]	Monilia albicans and metalochloriensis	B	[illegible]	Nyctalis asterophora	T[1]
130	Hormiscium dermatitidis	T	148	L. sepiaria	T[10,35]	[illegible]	Monilia fructicola	O[1]	[illegible]	Nyctalis gracilis	T
131	Hormodendrum algeriensis and pedrosoi	T	149	Lepiota melanthina and procera	T	[illegible]	M. [illegible]	T	[illegible]	Ophiobolus graminis	B T
132	H. langeroni	O	150	Lophodermium pinastri	B I[10] T	[illegible]	Monosporium apiospermum	O	[illegible]	O. miyabeanus	O
133	Hydnum spp.[30]	T	151	Madurella americana	O	[illegible]	Mortierella spp.	O	[illegible]	O. oryzinus	B
134	H. coralloides	O	152	Malassezia furfur	T	[illegible]	Mucor mucedo	T	[illegible]	[illegible]	B Pyr
135	Hypholoma spp.[31]	T	153	Marasmius androsaceus	B[10] T[5]	170	M. ramannianus	T[1]	[illegible]	O. [illegible]	T[3]
136	Hypochnus solani	O	154	M. perforans	B T	171	Mucor spp.[43]	O	[illegible]	O. [illegible]	Py[3]
137	Hypoxylon pruinatum	B T	155	Marasmius spp.[36]	T[9,22]	[illegible]	Mycena rubromarginata	O	[illegible]	Paecilomyces [illegible]	
138	Indiella americana	T	156	Martiniella panamensis	T[10]	173	M. sanguinolenta	O	[illegible]	Panus stipticus and torulosus	
139	Isoachlya monilifera	O	157	Melanconium betulinum	B I T	174	M. spp.[41]	T[42]	[illegible]	Paracoccidioides [illegible]	T
140	Kloeckera brevis	B I B Pan Pyr T	158	Melanospora destruens	B T	175	Mycelium radicis atrovirens	O	[illegible]	Paxillus [illegible]	
141	Lachnea pygmaeum	B T	159	Memnoniella echinata	B	[illegible]	Mycoderma lipolytica	T	[illegible]	Penicillium digitatum [illegible]	B[10] Pan[3] Pyr[10] T
142	Lactarius deliciosus	T				[illegible]	M. valida	B			
						[illegible]	Mycotorula lactis	B			
						[illegible]	Mycosphaerella [illegible] and grossulariae	O			
						[illegible]	M. [illegible]	T			
						182	Nectria coccinea	T[10]			

/1/ Requires only pyrimidine portion of thiamine molecule. /2/ Species include A. coerulea, A. glauca, A. [illegible], A. repens, A. [illegible] ... Species include A. gallinae, A. gypseum, A. schoenleinii. /4/ Plus an unknown "cofactor" which is not niacin or biotin. /5/ Can be replaced by pyrimidine and thiazole ... but by pyrimidine or thiazol. /6/ Species include A. dermatitis, A. furfuraceus, A. leveillei. /7/ In all species tested. /8/ Species include B. [illegible], B. granulatus, B. piperatus, B. variegatus, B. viscidus. /9/ Some species are only partially deficient in ... some synthesis of the vitamin presumably takes place. /10/ Partial requirement; some synthesis of the vitamin presumably takes place. /11/ Species include C. chalmersi, C. deformans, C. flareri, C. [illegible], C. [illegible], C. mycotoruloides, C. parakrusei, C. stellatoidea, C. zeylanoides. /12/ Species include C. albicans, C. aldoi, C. brumpti, C. [illegible], C. suaveolens, C. [illegible], C. [illegible]. /13/ Species include C. fimbriata. Two isolates of this species have been reported to require thiamine only. /14/ Species include C. [illegible], C. microspora, C. moniliformis, C. pedicillata, C. ploesporda, C. pini. /15/ Species include C. multiannulata, C. [illegible], C. [illegible], C. pseudotsugae, C. [illegible]. /16/ Species include C. bostrychodes, C. cochlioides, C. latum, C. globosum. /17/ Certain isolates. /18/ Species include C. alexandri, C. aurantiacus, C. laetipes, C. [illegible], C. [illegible], C. trops, C. infundibuliformis, C. nebularis, C. odora, C. pithyophila. /19/ Species include C. subulata, C. butyracea, C. tuberosa, [illegible]. /20/ The vitamin is probably only partially required. /21/ Can be replaced by pyrimidine or thiazol. /22/ Some species require pyrimidine and thiazol, others pyrimidine only. /23/ Species include C. bertholletiae, C. echinulata, C. [illegible]. /24/ Species include: D. confragosa, D. [illegible], D. unicolor [illegible]. /25/ Species include D. fabri, D. [illegible], D. [illegible], D. [illegible], D. [illegible]. /26/ Species include: F. annosus, F. igniarius, F. [illegible] ... /28/ In most species tested. /29/ Species include: H. gramineum, H. sativum, H. victoriae. /30/ Species include H. auriscalpium, H. [illegible], H. erinaceus. /31/ Species include H. [illegible], H. fasciculare, [illegible]; H. sublateritium. /32/ Species include L. [illegible], L. [illegible], L. viburni. /33/ Pyrimidine plus thiazol are equally as effective as thiamine; pyrimidine alone is less effective. /34/ Species include L. abietina, [illegible]; L. betulina, L. trabea, [illegible]. /35/ Might be replaced by pyrimidine. /36/ Species include: M. alliaceus, M. chordalis, M. epiphyllus, M. foetidus, M. fulvo-bulbillosus, M. graminum, M. peronatus, M. [illegible], M. putillus, M. [illegible], M. rotula, M. scorodonius. /37/ Species include: M. canis, M. ferrugineum, M. fulvum. /38/ Some isolates show partial thiamine deficiency. /39/ Requires only thiazol portion of thiamine molecule. /40/ Species include M. circinelloides, M. genevensis, M. griseocyanus, M. hiemalis, M. mucilagineus, M. stolonifer, M. [illegible]. /41/ Species include: M. alcalina, M. [illegible], M. cinerella, M. debilis, M. epipterygia, M. flavo-alba, M. galericulata, M. galopoda, M. lactea, M. [illegible], M. polygramma, M. rosella, M. vitosa, M. vulgaris, M. zephyra. /42/ In many species probably additional (partial) requirements. /43/ Species include M. [illegible], M. [illegible], M. stolophila, M. tetrasperma.

Data are applicable to vitamins which must be supplied each organism in its substrate. In each case, the organism synthesizes all other vitamins needed in its metabolism. 0 denotes that the organism synthesizes all the vitamins it requires. Certain species not listed in this table require growth substrates of yet unidentified nature which may be supplied by the addition of yeast extract or other complex organic materials. Different isolates of the same species may have different vitamin requirements.

Biotin (B); Inositol (I); Niacin (N); Pantothenic acid (Pan); Para-aminobenzoic acid (Pab); Pyridoxine (Pyx); Thiamine (T); None (0)

	Species (A)	Vitamins Required in Substrate (B)
199	Penicillium spp.[44]	0
200	Peniophora spp.[45]	T
201	Phacidium infestans	T[10]
202	Phialophora spp.[46]	T
203	Pholiota adiposa	B[10] Pyx[10] T[10]
204	P. mutabilis and squarrosa	T
205	Phoma apiicola and betae	0
206	Phycomyces blakesleeanus	T[47]
207	P. nitens	T
208	Phymatotrichum omnivorum	0
209	Phytophthora spp.[7]	T[48]
210	Pichia alcoholophila	B
211	P. belgica	B I Pyx T
212	P. dombrowskii	T
213	P. kluyveri	B T
214	Piedraia hortai	T
215	Pilaira anomala and moreaui	T
216	Piptocephalis freseniana	0
217	Piricularia oryzae	B T
218	Pityrosporum ovale	B T
219	Pleurage curvicolla	B T
220	Pleurotus corticatus	T
221	Podospora curvula	B T
222	Polyporus spraguei	0
223	Polyporus spp.[49]	T[50]
224	Polystictus versicolor	Pyx[10] T[51]
225	Psalliota bispora	B or T
226	P. campestris	0
227	Pseudopeziza ribis	B

	Species (A)	Vitamins Required in Substrate (B)
228	Pyronema confluens	T
229	P. domesticum	0
230	Pythiomorpha gonapodyoides	T[1]
231	P. oryzae	T[31]
232	Pythium spp.[52]	0
233	P. spp.[53]	T[52]
234	Rhizopogon roseolus	B[10] T
235	Rhizopus spp.[7]	0
236	Rhodotorula aurantiaca	Pab T[31]
237	R. aurea and glutinis	0
238	Rhodotorula spp.[54]	T
239	Rosellinia arcuata	B
240	R. necatrix and thelena	0
241	Sabouraudites gypseus and radiolatus	0
242	Saccharomyces carlsbergensis	B Pan
243	S. carlsbergensis mandshuricus	B Pan Pyx
244	S. cerevisiae ellipsoideus	B I Pan T
245	S. chodati	B Pan Pyx
246	S. fragilis	B Pan Pyx T
247	S. globosus	B N T
248	S. logos	Pan T
249	S. ludwigii	B I

	Species (A)	Vitamins Required in Substrate (B)
249	S. ludwigii (cont'd)	N Pan Pyx T
250	S. macedoniensis	B N Pan T
251	S. oviformis	B Pan Pyx
252	S. tubiformis	B Pan
253	S. uvarum	B I Pan
254	Saccobolus depauperatus	B
255	Saprolegnia delica	0
256	S. mixta	0
257	Schizophyllum commune	T
258	Schizosaccharomyces pombe	B I N Pan
259	Schwanniomyces occidentalis	B
260	Sclerotinia camelliae	B I[10] T
261	S. minor	B[10] T[60]
262	S. sclerotiorum	0
263	Sclerotium delphinii	T[1]
264	S. rolfsii	T[59]
265	Septoria apii	T[1]
266	Septoria spp.[55]	0
267	Sistotrema confluens	T
268	Sordaria fimicola[56]	B
269	S. fimicola[17]	B T
270	Spathularia flavida	B Pyx

	Species (A)	Vitamins Required in Substrate (B)
270	S. flavida (cont'd)	T
271	Spermophthora gossypii	0
272	Sphaerobolus stellatus	0
273	Sphaeropsis malorum	0
274	Sphaerulina trifolii	T
275	Sporormia intermedia	B
276	Sporotrichum schenckii	T
277	Sporotrichum spp.[57]	0
278	Stachybotrys atra	B
279	Stereum frustulosum	T[59]
280	S. murrayi	0
281	Stromatinia [illegible]	T[10]
282	Stropharia semiglobata	T
283	Syncephalastrum cinereum	0
284	Thamnidium elegans	0
285	Thielaviopsis basicola	T[11]
286	Thraustotheca clavata[17]	B
287	Tilletia horrida	T[5]
288	T. levis	0
289	T. tritici	T[58]
290	Torula cremoris	B N T
291	T. [illegible]	0
292	T. lactis	N
293	T. sphaerica	B N
294	T. fermentati and laurentii	T[51]
295	T. rosea and sanguinea	T
296	T. kefyr and pulcherrima	B
297	Torulaspora delbrueckii and fermentati	N
298	Torulopsis candida	B
299	T. dattila	B Pyx T
300	T. kefyr	N
301	T. laurentii and neoformans	T

500	[illegible] spp[59]	B	512	T. sulfureum	O	[illegible]	T. pini (cont'd)	T	532	Z. japonicus (cont'd)
501	Trachysphaera fructigena[60]	B		and violaceum	T	[illegible]	Venturia inaequalis	O	533	Z. lactis
502	Trametes spp	T	513	Trichophyton spp.[63]	T	[illegible]	Xylaria arbuscula	O		
503	Trichoderma lignorum	O	514	Trichosporon beigelii	B				534	Z. mandshuricus
					T	[illegible]	X. polymorpha	O		
506	Tricholoma spp[61]	T[9] CR	515	T. minor	T	[illegible]	X. hypoxylon	T	535	Z. marxianus
507	Trichophyton discoides	B				[illegible]	Zygorhynchus spp[66]	O		
		I	516	Tuber furfuracea	T	[illegible]	Zygosaccharomyces barkeri	B	536	Z. nadsonii
		Pyr	517	Typhula variabilis	T[1] 10			Pan		
		T	518	Ustilago longissima	T			T		
508	T. flaviforme	I	519	Ustilago spp[64]	T[3]	530	Z. bisporus	B	537	Z. pastori
		T	520	Ustilago spp[65]	O			T		
509	T. mentagrophytes[17]	O							538	Z. pini
510	T. mentagrophytes[17]	I	521	Ustilina vulgaris	O	531	Z. japonicus	B	539	Z. priorianus
		T	522	Valsa ceratophora	T[10]			I		
			523	T. pini	B			Pan		
511	Trichophyton spp.[62]	O			I					

Right column codes (as printed, top to bottom)	T, B, V, B, T, B, V, B, Pan, B, Pan, B, B, Z, Pan

/1/ Requires only pyridine portion of thiamine molecule /3/ Can be replaced by pyrimidine and thiazole but not by pyrimidine or thiazol /7/ All species tested. /9/ Some species are only partially deficient; some synthesis of the vitamin presumably takes place /10/ Partial requirement; some synthesis of the vitamin presumably takes place /17/ Certain isolates /20/ The vitamin probably only partially required. /22/ Some species require pyrimidine and thiazole, others pyrimidine only /27/ One strain only /39/ Requires only thiazole portion of thiamine molecule /44/ In all other species tested. /45/ Species include: P. candida, P. cinctula, P. fraxinea, P. junipericola, P. [illegible], P. violaceo-livida. /46/ Species include: P. compactum, P. [illegible], P. [illegible], P. verrucosa. /47/ Requires intact thiamine molecule or pyrimidine plus thiazole /48/ Most species require intact thiamine molecule; P. fagopyri needs only pyrimidine /49/ Species include: P. abietinus, P. adustus, P. [illegible], P. [illegible], P. [illegible], P. [illegible], P. fomentarius, P. [illegible], P. squamosus, P. [illegible] /50/ P. [illegible] requires only pyrimidine; most other species can grow with pyrimidine plus thiazole but P. [illegible] and P. [illegible] require intact thiamine molecule /51/ Requires intact thiamine molecule /52/ Species include: P. [illegible], P. [illegible], P. [illegible], P. hyphalosticton, P. intermedium, P. irregulare, P. mamillatum, P. sclerotichum, P. [illegible] /53/ Species include: P. [illegible], P. [illegible] cf Fa 50; P. butleri, P. oligandrum, P. polycladon, P. polymastum, cf Fa 50 /54/ Species include: R. flava, R. mucilaginosa, R. rubra, R. [illegible] /55/ Species include: S. [illegible], S. [illegible], S. [illegible], S. [illegible] /56/ Most isolates /57/ Species include: S. [illegible], S. [illegible] S. [illegible] /58/ There are conflicting reports in the species on the replaceability of thiamine by pyrimidine plus thiazole or by pyrimidine alone /59/ Species include: T. [illegible], T. minor, T. [illegible] /60/ Species include: T. [illegible], T. heteromorpha, T. [illegible] /61/ Species include: T. [illegible], T. brevipes, T. [illegible], T. [illegible], T. [illegible], T. imbricatum, T. [illegible], T. [illegible], T. [illegible], T. [illegible]. /62/ Species include: T. rubrum, T. [illegible], T. [illegible] /63/ Species include: T. [illegible], T. interdigitale, T. [illegible]. /64/ Species include: U. [illegible], U. scabiosae, U. [illegible], U. violacea; also 7 species closely related to U. violacea. /65/ Species include: U. [illegible], U. [illegible], U. hordei, U. levis, U. maydis, U. striiformis, U. tritici, U. zeae /66/ Species include Z. [illegible], Z. [illegible], Z. heterogamus, Z. moelleri

26 ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS BACTERIA

Required (R); Not required (R̸)

Vitamins and Related Substances (A) \ Organism	Aerobacter aerogenes (B)	Bacillus alvei (C)	B. anthracis (D)	B. brevis (E)	B. cereus (F)	B. cereus var mycoides (G)	B. circulans (H)	B. coagulans (I)	B. licheniformis (J)	B macerans (K)	B. megaterium (L)	B. pasteurii (M)
1 Vitamin A	R̸											
2 Ascorbic acid	R̸											
3 Biotin	R̸	R̸	R̸	R̸	R̸	R̸	R	R	R̸	R	R̸	R?
4 Choline	R̸											
5 Cobalamin[2]	R̸											
6 Vitamin D	R̸											
7 Vitamin E	R̸											
8 Folic acid group[3]	R̸											
9 Inositol	R̸											
10 Vitamin K	R̸											
11 Niacin[4]	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R[5]	R̸	R̸	R̸	R?
12 Pantothenic acid	R̸											
13 Para-aminobenzoic acid	R̸											
14 Pyridoxine group[6]	R̸											
15 Riboflavine	R̸											
16 Thiamine	R̸	R	R	R̸	R̸	R̸	R	R	R̸	R	R̸	R
17 Other substances	R̸											

Vitamins and Related Substances (A) \ Organism	B. polymyxa (N)	B. pumilis (O)	B. sphaericus (P)	B subtilis (Q)	B. subtilis var niger (R)	Brucella abortus (S)	B. melitensis (T)	B. suis (U)	Erwinia[1] (V)	E. amylovora (W)	E. tracheiphila (X)	Escherichia coli (Y)	Hemophilus influenzae (Z)
1 Vitamin A						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
2 Ascorbic acid						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
3 Biotin	R	R	R?	R̸	R̸	R	R	R	R̸	R̸	R̸	R̸	R̸
4 Choline						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
5 Cobalamin[2]						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
6 Vitamin D						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
7 Vitamin E						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
8 Folic acid group[3]						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
9 Inositol						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
10 Vitamin K						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
11 Niacin[4]	R̸	R̸	R̸	R̸	R̸	R	R	R	R̸	R	R[1]	R̸	R̸
12 Pantothenic acid						R	R	R	R̸	R̸	R̸	R̸	R̸
13 Para-aminobenzoic acid						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
14 Pyridoxine group[6]						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
15 Riboflavine						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸
16 Thiamine	R̸	R̸	R	R̸	R̸	R	R	R	R̸	R̸	R̸	R̸	R̸
17 Other substances						R̸	R̸	R̸	R̸	R̸	R̸	R̸	R[7]

/1/ Various strains /2/ A generi term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /3/ Foli acid i not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c, factor U L. casei factor Norite eluate factor /4/ The term i used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti blacktongue factor /5/ One strain only /6/ Includes pyridoxine pyridoxal pyridoxamine /7/ Hemin diphosphopyridine

ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS BACTERIA (Concluded)

Required (R); not required (R̸)

Vitamins and Related Substances / Organism	Hemophilus para-influenzae	Lactobacillus (hetero-fermentative)	L. (homo-fermentative)	Leuconostoc citrovorum	L. dextranicum	L. mesenteroides	Pasteurella multocida	P. pestis	P. pseudotuberculosis	P. tularense	Proteus morganii	P. vulgaris	P. X 19	Salmonella cholerae-suis	S. enteritidis	S. gallinarum	S. pullorum	S. schottmuelleri	S. typhosa	Serratia marcescens	Shigella alkalescens	S. paradysenteriae	S. sonnei	Staphylococcus albus	S. aureus
(1)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 Vitamin A									R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
2 Ascorbic acid									R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
3 Biotin		R	R	R	R	R	R[1]		R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸			R[8]	R[8]
4 Choline									R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
5 Cobalamin[2]		R[1] 9	R[1] 9						R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
6 Vitamin D									R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
7 Vitamin E									R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
8 Folic acid group[3]		R[1] 10	R[1] 10	R	R	R			R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
9 Inositol									R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
10 Vitamin K									R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
11 Niacin[4]		R	R	R[11]	R[11]	R[11]	R[12]		R̸		R	R	R[13]	R̸	R̸		R̸[1]	R̸	R̸	R̸	R̸	R[14]	R[14]	R	R
12 Pantothenic acid		R	R	R	R	R	R		R̸		R			R̸	R̸		R̸	R̸	R̸	R̸	R̸	R[1]	R[1]	R[8],15	R[8] 15
13 Para-aminobenzoic acid		R[1] 10	R[1] 10						R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
14 Pyridoxine group[6]		R[1] 10	R[1] 10	R[10] 15	R[10] 15	R[10] 15			R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸			R[8] 15	R[8] 15
15 Riboflavine		R̸	R	R[10] 15	R[10],15	R[10] 15			R̸					R̸	R̸		R̸	R̸	R̸	R̸	R̸				
16 Thiamine		R	R	R[10] 15	R[10] 15	R[10] 15			R̸	R[16]				R̸	R̸	R	R̸	R̸	R̸	R̸	R̸			R	R
17 Other substances	R[17]	R[18]	R[18]	R[19]	R̸	R̸		R[20]	R̸	R[22]				R̸	R̸		R̸	R̸	R̸	R̸	R̸				

/1/ Various strains /2/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /3/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c factor U L. casei factor Norite eluate factor /4/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti blacktongue factor /6/ Includes pyridoxine pyridoxal pyridoxamine /8/ Coagulase ( ) strains /9/ Or nucleotides /10/ Occasional requirement as growth stimulant /11/ Nicotinic acid for some strains only /12/ Nicotinamide /13/ Occasional strains have no known requirement /14/ Usually /15/ Occasionally /16/ Thiamine diphosphate /17/ Diphosphopyridine nucleotide; putrescine /18/ Some strains require pyridoxal phosphate and pantethine /19/ Citrovorum factor stimulates growth of strain 8081 /20/ Aerobic require hemin; anaerobic have no known requirements /21/ Adenosine among others

27 DAILY NUTRIENT ALLOWANCES MAN ADULT CANADA

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients needed to satisfy the physiological requirements of healthy 70 kg men and 56 kg women residing in Canada and obtaining the required nutrients from ordinary dietary sources Available data do not permit an estimate of the ordinary ranges of variation For persons whose body weights differ from 70 kg and 56 kg, recalculate each value (cf footnotes) Blank spaces indicate lack of data, not absence of requirement Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between species and does not necessarily imply a close correlation between nutrient need and body weight (but cf Fn 10) Requirements per kilogram body weight which appear to be affected by sex arise from the fact that maintenance requirement is related to weight but independent of sex, while work allowances are independent of weight and may differ with sex at different intensities of activity

	Specifications / Nutrients per kg body weight per day	Required (R)								
		♂70 kg	♀56 kg	♂70 kg	♀56 kg	♂70 kg	♀56 kg	♂70 kg	♀65 kg	♀56 kg
		Sedentary		Moderate Activity		Heavy Activity		Very Heavy Activity	Pregnancy[1]	Lactation[2]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1	Water[3 4] ml	35	38	43	43	54	52	68	40	56
2	Calories metabolizable[5 6]	35	38	43	43	54	52	68	40	56
3	Total food (dry)[3 7] g	7 6	8 2	9.2	9 3	10 8	10 5	13 7	8 6	11.9[8]
4	Residue									
5	Protein[9 10] g	0 96	1 0	0 96	1 0	0 96	1.0	0 96	1 3	1 5
6	Carbohydrate[3 11] g	5 7	6 1	7.1	7.1	7 7	7 4	7 2	6.3	9.0[8]
7	Fat[3 12] g	1.0	1 1	1.2	1 2	2 1	2 0	2 6	1.1	1 6[8]
8	"Essential" fatty acids									
9	Vitamin A as β-carotene[10 13] µg	43	43	43	43	43	43	43	55	66
10	Ascorbic acid[14 15] mg	0 43	0 54	0 43	0 54	0 43	0 54	0 43	0 46	0 54
11	Biotin									
12	Choline									
13	Cobalamin[16]									
14	Vitamin D, cals as calciferol[14 17] µg								0.16	0.18
15	Vitamin E[18]									
16	Folic acid group[19]									
17	Inositol									
18	Vitamin K[20]									
19	Niacin[3 21] mg	0.11	0.12	0 13	0 14	0.16	0 16	0.21	0.13	0.17
20	Pantothenic acid									
21	Para-aminobenzoic acid									
22	Pyridoxine group[22]									
23	Riboflavin[3 23] µg	17	18	22	20	25	25	32	20	27
24	Thiamine[3,24] µg	11	12	13	14	16	16	21	14	17

25	Calcium[10] mg	10	10	10	10	10	10	10	25	28
26	Chlorine[14,25] mg	43	54	43	54	43	54	43	46	54
27	Cobalt	R	R	R	R	R	R	R	R	R
28	Copper									
29	Fluorine	4	4	4	4	4	4	4	4	4
30	Iodine[10 26] µg	0 086	0 214	0 086	0 214	0 086	0 214	0,086	0 251	0,268
31	Iron[14,27] mg									
32	Magnesium									
33	Manganese									
34	Molybdenum									
35	Phosphorus[10 28] mg	10	10	10	10	10	10	10	25	28
36	Potassium									
37	Silicon									
38	Sodium[14,25] mg	28	36	28	36	28	36	28	31	36
39	Sulfur									
40	Zinc									

/1/ Values are for sedentary activity plus added allowances for last half of pregnancy /2/ Sedentary activity" plus added allowance /3/ Calorie-correlated. /4/ Breaks calorie-correlation of 1 ml per kilocalorie of food in excessively hot environment /5/ For adult man or woman maintenance Calories (weight-correlated cf Fn 10) 1 33 x basal metabolism $93(W^{0.75})$ where W is body weight in kilograms To maintenance Calories add per person; for sedentary work ♂225 ♀225; moderate work ♂750 ♀500; heavy work ♂1500 ♀1000; very heavy work, ♂2500; pregnancy latter half 500; lactation 1000 /6/ Kilocalories net utilizable for heat and total activity The coefficients 4 0 4.0 and 9 0 have been used for calculating the kilocalorie value of ingested grams of protein carbohydrate and fat (5A,6A,7A) /7/ Sum of 5A,6A,7A each carried to two decimal places Rounding off of these as presented introduces apparent discrepancy between them and their sum. /8/ If fat taken as 35% of Calories 5J 11 3 6J = 7 6, 7J 2.2 /9/ Allow protein (grams) $2.75(W^{0.75})$ where W is body weight in kilograms /10/ Correlated with body weight /11/ Calculated by: 2A minus Calori value of 5A and 7A, the remainder divided by 4.0 (cf Fn 6) /12/ Calculated by: 25% of 2A divided by 9.0 (cf Fn 6) except col. FUK where assumed 35%. /13/ Allow 18 I U of preformed A (0 3 µg A alcohol = one I U) or 72 I U of β-carotene (0 6 µg = one I U) per kg body weight /14/ Neither weight- nor calorie-correlated! Allowance for ♂70kg or ♀56kg applies to adults of other body weights /15/ Allow 30 mg/person. /16/ Generic term including cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity /17/ 0 025 µg calciferol one I U Little or no dietary intake needed by adults except elderly people and those who are prevented from exposure to direct sunlight /18/ A generic term for alpha beta delta- and gamma tocopherols /19/ Folic acid a generic term for pteroylglutamic acid (PGA, folacin) and pteroylglutamates Also known as vitamin M, B_c; L. casei factor Norite eluate factor /20/ The anti-hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione; 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1,4-naphthoquinone) /21/ Generic term for nicotinic acid (niacin) nicotinic acid amide (nicotinamide) pellagra preventive (P.P) factor Allow 3 µg/Calorie (cf 2A) /22/ Includes pyridoxine, pyridoxal and pyridoxamine /23/ Allow 0 3 µg/Calorie (cf 2A) /24/ Allow 0 3 µg/Calorie (cf 2A) /25/ Allow 5g NaCl/person. /26/ Allow up to 4 µg/kg /27/ Allow ♂6 ♀12mg/person 15 in pregnancy and lactation /28/ Same values as those for calcium.

28 DAILY NUTRIENT ALLOWANCES MAN, CHILDHOOD, CANADA

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients needed to satisfy the physiological requirements of healthy juveniles of average activity residing in Canada and obtaining all required nutrients from ordinary dietary sources. Available data do not permit an estimate of the ordinary range of variation. To calculate allowances per person, multiply values in appropriate column by kg of actual body weight. Blank spaces indicate lack of data, not absence of requirement. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight. Requirements per kilogram body weight which appear to be affected by sex arise from the fact that maintenance requirement is related to weight but independent of sex while work allowances are independent of weight and may differ with sex at different intensities of activity.

	Specifications / Nutrients per kg body weight per day	Required (E) 1-3 yr	4-6 yr	7-9 yr	10-12 yr		13-15 yr		16-20 yr[1]	
		♂12 kg	♂19 kg	♂26 kg	♂34 kg	♀37 kg	♂49 kg	♀49 kg	♂60 kg	♀53 kg
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1	Water[2, 3] ml	104	86	78	69	68	60	51	58	45
2	Calories metabolizable[4, 5, 6]	104	86	78	69	68	60	51	58	45
3	Total food (dry)[2, 7] g	22.4	18.5	16.8	15.3	14.6	13.0	10.9	11.8	9.8
4	Residue									
5	Protein[4, 8] g	3.1	2.0	1.9	1.8	1.7	1.5	1.5	1.0	1.0
6	Carbohydrate[2, 9] g	16.4	14.1	12.7	11.5	11.0	9.8	8.0	8.5	7.5
7	Fat[2, 10] g	2.9	2.4	2.2	2.0	1.9	1.7	1.4	2.3	1.3
8	"Essential" fatty acids									
9	Vitamin A as β-carotene[4, 11] µg	43.2	43.2	43.2	43.2	43.2	43.2	43.2	43.2	43.2
10	Ascorbic acid[12, 13] mg	2.5	1.6	1.15	0.88	0.81	0.61	0.61	0.50	0.57
11	Biotin									
12	Choline									
13	Cobalamin[14]									
14	Vitamin D, sale as calciferol[12, 15] µg	0.82 1.65	0.52	0.38	0.29	0.27	0.20	0.20		
15	Vitamin E[16]									
16	Folic acid group[17]									
17	Inositol									
18	Vitamin K[18]									
19	Niacin[2, 19] mg	0.31	0.26	0.23	0.21	0.20	0.18	0.15	0.17	0.14
20	Pantothenic acid									
21	Para-aminobenzoic acid									
22	Pyridoxine group[20]									
23	Riboflavin[2, 21] µg	52	43	39	35	34	30	29	29	22
24	Thiamine[2, 22] µg	31	25	23	21	20	18	15	17	14

45	Calcium[23] mg	83	53	38	29	29	31	31	25	28
46	Chlorine[24]	R	R	R	R	R	R	R	R	R
47	Cobalt									
48	Copper	R	R	R	R	R	R	R	R	R
49	Fluorine									
50	Iodine µg	4	4	4	4	4	4	4	4	4
51	Iron[25] mg	0 5	0 32	0.23	0 18	0.17	0.24	0.24	0.20	0.23
52	Magnesium									
53	Manganese									
54	Molybdenum									
55	Phosphorus[23] mg	83	53	38	29	29	31	31	25	28
56	Potassium									
57	Silicon									
58	Sodium[24]	R	R	R	R	R	R	R	R	R
59	Sulfur									
60	Zinc									

/1/ Based on values calculated for adults ♂60kg, ♀55kg assumed to be doing ♂heavy or ♀moderate to heavy work /2/ Calorie-correlated /3/ Allow 1 ml/ Calorie /4/ Correlated with body weight /5/ Kilocalories net utilizable for heat total activity and growth 4.0P 4.00 + 9 0F where PCF represent grams of protein, carbohydrate and fat ingested (5A,6A 7A) /6/ Values for 21J based on maintenance Calories ♂2000, ♀1800 plus allowance of ♂1500 ♀600 for average activity (cf Fn 1 this table and Fn 5 preceding table for adults Canada) /7/ Sum of 5A,6A,7A. /8/ Based on survey data in which normal growth was the criterion of adequacy /9/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4 0 (cf Fn 3) /10/ Calculated by: 25% of 2A divided by 9.0 (cf Fn 3) except in col I where assumed 35%. /11/ Allow 18 I U of preformed A (0 3 µg A alcohol one I U) or 72 I U of β-carotene (0 6 µg one I U) per kg body weight /12/ Neither weight nor calorie-correlated? /13/ Allow 30 mg/person. /14/ Generic term for cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity /15/ Allow 400-800 I U /person up to age 3 yrs 400 I U thereafter to age 16 (0 025 µg calciferol one I. U) /16/ Generic term for alpha beta- delta and gamma tocopherols /17/ "Folic acid, generic term for pteroylglutamic acid (PGA; folacin) and pteroylglutamates Also known as vitamin M B_c; L. casei factor Norite eluate factor /18/ The anti-hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione; 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1 4-naphthoquinone) /19/ Generic term for nicotinic acid (niacin) nicotinic acid amide (nicotinamide) pellagra preventive (P.P) factor Allow 5 0 µg/Calorie /20/ Includes pyridoxine pyridoxal and pyridoxamine /21/ Allow 0 5 µg/Calorie /22/ Allow 0 3 µg/Calorie /23/ Allow 1g/person up to age 13; 1 5g up to age 16. /24/ Allow 5g NaCl/person for adults /25/ Allow 6 mg/person up to age 13; 12 mg thereafter

29 DAILY NUTRIENT ALLOWANCES MAN ADULT UNITED KINGDOM

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients deemed sufficient to establish and maintain a good nutritional state in healthy persons residing in the United Kingdom and obtaining the required nutrients from ordinary dietary sources Available data do not permit an estimate of the ordinary range of variation but the allowances estimated to be adequate for representative members of the several specified activity groups may need to be increased for some members of each group. Blank spaces indicate lack of data not absence of requirement Presentation of values in terms of per kg body weight per day" is for purposes of comparison between species and does not necessarily imply a close correlation between nutrient need and body weight

	Specifications / Nutrients per kg body weight per day	Required (R)										
		♂65 kg	♀56 kg	♂65 kg	♀56 kg	♂65 kg	♀56 kg	♂65 kg	♀56 kg	♂65 kg	♀65 kg	♀56 kg
		Over 65 yr	Over 60 yr	Sedentary		Moderately Active		Active		Very Active	Pregnancy[1]	Lactation
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
1	Water											
2	Calories[2] metabolizable	35	36	39	38	46	45	54	54	65	42	54
3	Total food (dry)[3,4] g	7.5	7.7	8.3	8.1	9.9	9.6	10.8	10.8	13.2	9.1	11.5
4	Residue											
5	Protein[3,5] g	1.0	1.0	1.1	1.0	1.3	1.2	1.5	1.5	1.8	1.5	2.0
6	Carbohydrate[3,6] g	5.5	5.7	6.2	6.0	7.4	7.1	7.3	7.2	8.8	6.5	8.1
7	Fat[3,7] g	1.0	1.0	1.1	1.0	1.3	1.2	2.1	2.1	2.5	1.2	1.5
8	"Essential" fatty acids											
9	Vitamin A and β-carotene[8,9] μg	38.5	44.6	38.5	44.6	38.5	44.6	38.5	44.6	38.5	46.2	71.4
10	Ascorbic acid[9,10] mg	0.31	0.4	0.31	0.4	0.31	0.4	0.31	0.4	0.31	0.6	0.9
11	Biotin											
12	Choline											
13	Cobalamin[11]											
14	Vitamin D calc. as calciferol[9,12] μg	R	R	R	R	R	R	R	R	R	0.16-0.23	0.36
15	Vitamin E[13]											
16	Folic acid group[14]											
17	Inositol											
18	Vitamin K[15]											
19	Niacin[3,16] mg	0.14	0.14	0.15	0.14	0.18	0.18	0.22	0.21	0.26	0.17	0.25
20	Pantothenic acid											
21	Para-aminobenzoic acid											
22	Pyridoxine group[17]											
23	Riboflavin[3] μg	22	21	23	23	28	27	32	32	40	25	36
24	Thiamine[3] μg	14	14	15	14	18	18	22	21	26	17	25

45	Calcium[9,18] mg	12	14	12	14	12	14	12	14	12	23	36
46	Chlorine											
47	Cobalt											
48	Copper											
49	Fluorine											
50	Iodine[9,19] µg	1 5	1 8	1 5	1 8	1 5	1 8	1 5	1.8	1 5	2 3	2 7
51	Iron[9 20] mg	0 185	0.214	0.185	0.214	0.185	0.214	0.185	0.214	0 185	0.231	0.268
52	Magnesium											
53	Manganese											
54	Molybdenum											
55	Phosphorus											
56	Potassium											
57	Silicon											
58	Sodium											
59	Sulfur											
60	Zinc											

/1/ Last half of pregnancy Body weight assumed /2/ Kilocalories net utilizable for heat and total activity The coefficients 4 0 4 0 and 9 0 have been used for calculating the kilocalorie value of ingested grams of protein carbohydrate and fat (5A,6A,7A) /3/ Calorie-correlated /4/ Sum of 5A,6A, 7A, each carried to two decimal places Rounding off of these as presented introduces apparent discrepancy between them and their sum /5/ Allow protein Calories 11% of 2A except in columns K where 14%, and L where 14 9% /6/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4 (cf Fn 2) /7/ Calculated by: 29% of 2A divided by 9 (cf Fn 2) for col B-G and KL and 33% similarly treated for HIJ /8/ Allow 5000 I U of mixture/person Average diet assumed to contain 20% by weight of preformed A (0 3 µg A alcohol = one I U) and 80% of β-carotene (0 6 µg one I U) the mixture averaging 0 5 µg one I U If dietary carotene is only 33% utilized (as is assumed) 0 9 µg of the mixture is worth one I U in effective activity If diet contains only preformed A, allow 30% of the value in table; if only β-carotene add 80% to value given /9/ Neither weight nor calorie-correlated? Allowance for 65 kg or 55 kg applies to adults of other body weights /10/ Allow 20 mg/person /11/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity /12/ 0.025 µg calciferol one I U /13/ A generic term for alpha beta delta and gamma tocopherols /14/ "Folic acid a generic term for pteroylglutamic acid (PGA, folacin) and pteroylglutamates Also known as vitamin M B_c; L casei factor, Norite eluate factor /15/ The anti-hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione; 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1 4-naphthoquinone) /16/ Generic term for nicotinic acid (niacin) nicotinic acid amide (nicotinamide) pellagra preventive (P P) factor /17/ Includes pyridoxine pyridoxal and pyridoxamine /18/ Allow 0 8 g/person /19/ Allow 100 µg/person /20/ Allow 12 mg/person

30 DAILY NUTRIENT ALLOWANCES MAN, INFANCY AND CHILDHOOD, UNITED KINGDOM

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients deemed *sufficient* to establish and maintain a good nutritional state in healthy persons residing in the United Kingdom and obtaining the required nutrients from ordinary[1] dietary sources. Available data do not permit an estimate of the ordinary range of variation but the allowances, estimated to be adequate for representative members of the several specified age groups, may need to be increased for some members of each group. Blank spaces indicate lack of data, not absence of requirement. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between species and does not necessarily imply a close correlation between nutrient need and body weight.

Specifications / Nutrients per kg body weight per day	Children to 12 yr					Children 13-20 yr			
	<1 yr	1-3 yr	4-6 yr	7-9 yr	10-12 yr	13-15 yr		16-20 yr	
	♂8 kg	♂12 kg	♂18 kg	♂27 kg	♂35 kg	♂49 kg	♀49 kg	♂63 kg	♀54 kg
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1 Water									
2 Calories metabolizable[2]	100	108	89	72	70	64	56	54	46
3 Total Food (dry)[3] g	21.5	23.3	19.2	15.5	15.0	13.8	12.2	11.7	10.0
4 Residue									
5 Protein[4, 5] g	3.5	3.8	3.1	2.5	2.5	2.2	2.0	1.9	1.6
6 Carbohydrate[4, 6] g	15.2	16.5	13.6	11.0	10.5	9.8	8.6	8.2	7.1
7 Fat[4, 7], g	2.8	3.0	2.5	2.0	2.0	1.8	1.6	1.6	1.3
8 "Essential" fatty acids									
9 Vitamin A and β-carotene[8] µg	56[9]	185	83.3	55.5	43	30.6	30.6	30.7	46.3
10 Ascorbic acid, mg	1.2	1.2	0.8	0.7	0.7	0.6	0.6	0.5	0.6
11 Biotin									
12 Choline									
13 Cobalamin[10]									
14 Vitamin D, calc as calciferol[11] µg	2.5	0.82	0.56	0.37	0.28	0.20	0.20	0.16	0.19
15 Vitamin E[12]									
16 Folic acid group[13]									
17 Inositol									
18 Vitamin K[14]									
19 Niacin[4,15], mg	0.37	0.42	0.33	0.30	0.29	0.27	0.22	0.22	0.18
20 Pantothenic acid									
21 Para-aminobenzoic acid									
22 Pyridoxine group[16]									
23 Riboflavin[4, 17], µg	62	67	56	44	43	39	33	33	20
24 Thiamine[4, 18], µg	37	42	33	30	29	27	22	22	18

		185	85	56	37	34	29	27	22	18
45	Calcium, mg									
46	Chlorine									
47	Cobalt									
48	Copper									
49	Fluorine									
50	Iodine[19] µg		12.5	8 3	5.6	4 3	3.1	3 1	2.4	2.8
		0 75	0 58	0 44	0.37	0.34	0.31	0.31	0.24	0.28
51	Iron mg									
52	Magnesium									
53	Manganese									
54	Molybdenum									
55	Phosphorus									
56	Potassium									
57	Silicon									
58	Sodium									
59	Sulfur									
60	Zinc									

/1/ Including certain supplementary nutrients for infants and children (cod liver oil vitamin A and D tablets orange juice) /2/ Kilocalories net utilizable for heat total activity and growth. The coefficients 4.0 4.0 and 9 0 have been used for calculating the kilocalorie value of ingested grams of protein carbohydrate and fat (3A,6A,7A) /3/ Sum of 3A,6A,7A. /4/ Calorie-correlated /5/ Allow protein Calorie 14% of 2A, and divide by 4 (cf Fn 2) /6/ Calculated by: 2A minus Calorie value of 3A and 7A, the remainder divided by 4 (cf Fn 2) /7/ Allow 25% (or more) of 2A and divide by 9 (cf Fn 2) /8/ Allow 3000 I U of mixture (or 1500 I U of preformed vitamin A) per person except for ages 16-80 years where allow 5000 I U of the mixture, or 2500 I U of A (See Fn 8 previous table) /9/ 56 µg preformed A (milk diet) during first year equivalent to 188 µg of mixed A and β-carotene in ordinary diet (See Fn 8 previous table) /10/ A generic term including cyanocobalamin (vitamin B12) and its hydrogenation product (B12a, B12b) which has approximately the same biological activity /11/ Allow 800 I U /person for age 1 yr 400 thereafter (0 025 µg calciferol one I U) /12/ A generic term for alpha- beta- delta- and gamma-tocopherols /13/ "Folic acid a generic term for pteroylglutamic acid (PGA folacin) and pteroylglutamates Also known as vitamin M B$_c$; L. casei factor Norite eluate factor /14/ The anti-hemorrhagic factor A generic term for vitamin K$_1$ (2-methyl 3-phytyl-1,4-naphthoquinone) synthetic vitamin K (menadione; 2-methyl 1 4-naphthoquinone) and vitamin K$_2$ (2-methyl 3-difarnesyl 1 4-naphthoquinone) /15/ Generic term for nicotinic acid (niacin) nicotinic acid amide (nicotinamide) pellagra preventive (P.P) factor Allow 4 µg/Calorie /16/ Includes pyridoxine pyridoxal and pyridoxamine /17/ Allow 0 6 µg/Calorie /18/ Better correlated with non-fat Calories than with Calories in 2A. Allow 0.4 µg/Calorie (or 0 6 µg/non-fat Calorie) /19/ Allow 150 µg/person

31 DAILY NUTRIENT ALLOWANCES MAN, ADULT, U S A

Nutrient needs vary from person to person as do other biological quantities, and are most suitably represented for any population by a mean value for each nutrient followed by a lower and an upper limit of the ordinary range of variation In the absence of actually measured means and ranges the table presents estimates estimated means for the values in lines 1 2,3 6 7 and 25 and estimates exceeding the upper limits of the ordinary range (estimate d of the 95% range; cf Introduction) for remaining values Estimates are for healthy persons living in the USA and obtaining all required nutrients from ordinary dietary sources (but cf Fn 26 30) To calculate all allowances for calorie-correlated items use ideal weight (based on height) instead of actual weight and correct for climate (Fn 6) and activity (Fn 7) For other nutrients use standard weight at top of column Presentation of values in terms of per kg body weight per day" is for purposes of comparison between man and other species and does not necessarily imply a close or linear correlation between nutrient need and body weight

Required (R)

	Nutrients per kg body weight per day / Specifications	Adults Normally Vigorous and Living in a Temperate Climate							
		25 yr		45 yr		65 yr		Pregnancy[1]	Lactation
		♂65 kg	♀55 kg	♂65 kg	♀55 kg	♂65 kg	♀55 kg	♀65 kg	♀55 kg
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
1	Water[2 3] ml	49	42	45	38	40	33	42	60
2	Calories metabolizable[4 5 6 7]	49	42	45	38	40	33	42	60[8]
3	Total food[2 9] (dry) g	10 8	9 0	9 8	8 2	8 8	7 0	9 3	12 9
4	Residue[9]								
5	Protein[10] g	1	1	1	1	1	1	1 2	1 8
6	Carbohydrate[2 11], g	8 5	7 1	7 6	6 4	6 8	5 5	7 0	9 8
7	Fat[2 12] g	1 1 1 4	0 8-1 0	1 0-1 2[+]	0 7-0 9	0 9-1 1	0 6-0 8	0 9-1.2	1.1 1 4
8	Essential fatty acids	R?	R?	R?	R?	R?	R?	R?	R?
9	Vitamin A and β-carotene[10,14] µg	41 5	49 1	41 5	49 1	41 5	49 1	46 8	78 5
10	Ascorbic acid[15,16] mg	1.15	1 25	1 15	1 25	1.15	1 25	1.55	2 75
11	Biotin[17]	R	R	R	R	R	R	R	R
12	Choline[18,19]								
13	Cobalamin[20]	R?	R?	R?	R?	R?	R?	R?	R?
14	Vitamin D[15] calc as calciferol[21,22] µg								
15	Vitamin E[18 23]	R	R	R	R	R	R	0 15	0.18
16	Folic acid group[17 24]	R?	R?	R?	R?	R?	R?	R?	R?
17	Inositol[18]								
18	Vitamin K[17 25,26]	R	R	R	R	R	R	15 5[26]	R
19	Niacin[2 17 27] mg	0 25	0 22	0 21	0 18	0 18	0 18	0 31	0 27
20	Pantothenic acid[18 28]	R	R	R	R	R	R	R	R
21	Para-aminobenzoic acid								
22	Pyridoxine group[17,29 30] µg	15-31	18-36	15-31	18-36	15-31	18-36	15-31	18-36
23	Riboflavine[10 31] µg	25	26	25	26	45	26	31	46
24	Thiamine[2 32] µg	25	22	21	18	18	18	25	27

45 Calcium mg	12	14	18	14	12	14	23	36
46 Chlorine[15, 33] mg	95	88	95	88	95	88	88	88
47 Cobalt[34]	NT	NT	NT	NT	NT	NT	NT	NT
48 Copper[15, 35] µg	18	21	18	21	18	21	25	27
49 Fluorine[18]	2-4	~-4	2-4	2-4	2-4	2-4	2-4	2-4
50 Iodine[15, 36] mg	0 18	0.21	0 18	0 21	0 18	0 21	0 25	0 27
51 Iron[15] mg	NT	NT	NT	NT	NT	NT	NT	NT
52 Magnesium	NT	NT	NT	NT	NT	NT	NT	NT
53 Manganese	NT	NT	NT	NT	NT	NT	NT	NT
54 Molybdenum	18	21	18	21	18	21	25	36
55 Phosphorus[15, 37] mg	R	R	R	R	R	R	R	R
56 Potassium	60	57	60	57	60	57	57	57
57 Silicon	R	R	R	R	R	R	R	R
58 Sodium[15, 33] mg	NT	NT	NT	NT	NT	NT	NT	NT
59 Sulfur								
60 Zinc								

/1/ Toward end of pregnancy Weight = 55 kg, plus 10 kg of placenta, amniotic fluid, uterus fetus and additional body water /2/ Calorie-
correlated. /3/ Calorie-correlation breaks in excessively hot environment the value rising to extremes of 100-200 ml/kg /4/ Kilocalo-
ries not utilizable for heat and total activity (and growth) = either 4 1P_a + 4 1C_a + 9 F_a or 4 CP_1 + 4 CC_1 + 9 CF_1 where PCF represent
grams of protein, carbohydrate and fat and the subscripts i = ingested and a = virtually absorbed (i e ingested PCF minus fecal PCF)
The coefficient 4 1 for P_a allows for loss of 22% of P_a Calories in the urine (urea, etc) /5/ Adjustment for weight: If W the ideal
weight for a person s height differs from the standard weight at 1) head of column, add or 7%, or 97 % to Calories for 10 kg underweight;
subtract 65 5% or 95 7% for 10 kg overweight or calculate total Calories as 152 ($W^{0.75}$) 125 4 ($W^{0.75}$) /6/ Adjustment for climate: Add
5% to Calories (columns B-G) for extreme northern U S.A.; subtract 5% for southern U S.A. No climate correction if mean annual temperature
= 10° C /7/ Adjustment for activity: For normally vigorous daily activity make no correction; for sedentary life reduce Calories by
20%; for heavy work, add 20-25%; for heaviest work, add 50% /8/ Assuming daily milk production of 850 ml at energy expenditure of 150
Cal per 100 ml milk produced /9/ 3A = sum of 5A, 6A, 7A. "Residue lost in feces 8% of 5A 3% of 6A + 5% of 7A, = approximately 3 5-
4% of 3A. /10/ Correlated with body weight /11/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4
(cf Fn 4) /12/ Taken as 20-25% of 2A divided by 9 (cf Fn 4) Proportion of Calories from fat taken as 30-35% for persons engaged in
heavy work (cf Fn 7) /14/ Allow 5000 I U per person derived from average diet assumed to contain 11% by weight of preformed A (0 3 µg
A alcohol = one I U) and 89% of β-carotene (0 6 µg = one I U) 0 54 µg of this mixture = one I U If dietary carotene is only 50%
utilized (as is assumed) the mixture has an effective activity of 0 9 µg = one I U If diet contains only preformed A allow 0.33 x value
in the table; if only β-carotene allow 1 33 x value given. /15/ Neither weight nor calorie-correlated? Allowance for 65 kg or 55 kg
applies to other adult body weights /16/ Allow 75 mg 70mg/person. /17/ Some synthesis by intestinal flora. /18/ Definite requirement
by man not conclusively demonstrated. /19/ Synthesized in adequate? amounts by transmethylation from methionine or betaine to ethanolamine
/20/ Generic term including cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological
activity /21/ Little need for adults except elderly persons and those whose habits prevent exposure to sunlight (night workers nuns etc)
/22/ 0 025 µg calciferol one I U /23/ A generic term for alpha- beta- delta and gamma tocopherols /24/ Folic acid" a generic
term for pteroylglutamic acid (PGA; folacin) and pteroylglutamates Also known as vitamin M, B_c; L. casei factor Norite eluate factor A
daily dietary intake of less than 1 mg/person is probably sufficient /25/ The antihemorrhagic factor A generic term for vitamin K_1 (2-
methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione; 2-methyl 1 4-napthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1
4-naphthoquinone) /26/ Last month of pregnancy as dietary supplement to raise fetal blood prothrombin (vs birth hemorrhages) /27/ Ge-
neric term for nicotinic acid (niacin) nicotinic acid amide (nicotinamide) pellagra preventive (P P) factor Some? formation from
tryptophan. Allow 10 x 24A. /28/ Requirement practically certain but not demonstrated Component of Coenzyme A. Good diet supplies
approximately 4 mg per 1000 Cal /29/ Includes pyridoxine pyridoxal and pyridoxamine /30/ Some evidence of defect in metabolism of
pyridoxine in pregnancy; dietary supplement possibly of value? /31/ Allow 25 µg/g of protein. /32/ Allow 0 5 µg/Calorie /33/ Assumed
allowance; 10 g NaCl for physically active man 8 g for moderately active woman; but 5 g NaCl is considered a liberal allowance except
for persons who sweat profusely as those engaged in heavy work /34/ Required only as cobalamin? /35/ Allow 10% of 31A. /36/ Values
given are probable requirement greater in pregnancy? /37/ Allow 1 5 x 24A except for col H where allow 1 x 25A.

32 DAILY NUTRIENT ALLOWANCES MAN, INFANCY AND CHILDHOOD, U S A

The allowances listed are designed to maintain good nutrition of healthy persons in the U S A In their application to individual persons the allowances should be modified, if necessary to take account of growth rate physical development and state of nutrition. Presentation of values in terms of per kg body weight per day" is for purposes of comparison only, and does not necessarily imply a close or linear correlation between nutrient need and body weight

		Required (R)											
	Specifications	Children to 9 yr						Children 10-20 yr					
	Nutrients per kg body weight per day	1 3 mo[1]	4-9 mo[1]	10 mo-1 yr	1 3 yr	4-6yr	7 9 yr	10-12 yr		13 15 yr		16-20 yr	
		♂♀5 kg	♂♀8 kg	♂♀10 kg	♂♀12 kg	♂♀18 kg	♂♀27 kg	♂35 kg	♀36 kg	♂49 kg	♀49 kg	♂63 kg	♀54 kg
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
1	Water[3 4] ml	120	110	100	100	89	74	71	64	65	51	60	44
2	Calories metabolizable[5]	120	110	100	100	89	74	71	64	65	51	60[2]	44[8]
3	Total food[4 6] (dry) g	25 3	22 6	20 5	20 4	18 2	15 2	14 7	12 5	13 5	10 4	12.3	9 1
4	Residue[6]												
5	Protein[7] g	3 5[8]	3 5[8]	3 5	3 3	2 8	2 2	2 0	1 9	1 7	1 6	1 6	1.4
6	Carbohydrate[4 9] g	17 5	15 1	13 4	13 5	12 2	10 3	10 1	8 6	9 3	7 0	8 6	6 1
7	Fat[4 10] g	4 0-4 7	3 7-4 3	3 3-3 9	3 3 3 9	3 0-3 5	2 5-2 9	2 4-2 8	2 1 2.5	2 2-2.5	1 7 2 0	2.0-2 3	1 5-1 7
8	"Essential fatty acids	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
9	Vitamin A, and β-carotene[7 12] μg	54[13]	33 8[13]	81.0	90 0	75 0	70 0	66 6	64 7	55 1	55 1	42 9	50 0
10	Ascorbic acid, mg	6 0	3 8	3 0	2 9	2 8	2.2	2 1	2 1	1 8	1 6	1 6	1 5
11	Biotin[14]	R	R	R	R	R	R	R	R	R	R	R	R
12	Choline												
13	Cobalamin[15]	R	R	R	R	R	R	R	R	R	R	R	R
14	Vitamin D calc as calciferol[16,17] μg	2 0	1 25	1 0	0 83	0 55	0 37	0 28	0 28	0 20	0 20	0 16	0 18
15	Vitamin E[18]												
16	Folic acid group[14 19]	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
17	Inositol												
18	Vitamin K[14 20] μg	R	R	R	R	R	R	R	R	R	R	R	R
19	Niacin[14 21] mg	0 60	0 55	0 5	0 5	0 44	0 37	0 37	0 33	0 31	0 26	0 30	0 22
20	Pantothenic acid[22]	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
21	Para-aminobenzoic acid												
22	Pyridoxine group[14 23] μg	R	R	R	R	R	R	R	R	R	R	16-38	19-38
23	Riboflavin[7 24] μg	80	89	90	83	69	56	51	50	43	41	39	35
24	Thiamine[4 25] μg	60	55	50	50	44	37	36	33	32	26	30	22

25	Calcium[16] mg	100	100	100	85	56	57	54	53	28	26	22	24
26	Chlorine[16]	R	R	R	R	R	R	R	R	R	R	R	R
27	Cobalt[25]	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
28	Copper[16] µg	50	50	50	50	50	50	50	50	50	50	18-50	21 50
29	Fluorine												
30	Iodine[16,27] µg	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
31	Iron[16], mg	1.2	0 75	0 6	0 58	0 42	0 58	0 54	0 54	0 51	0 31	0,24	0 28
32	Magnesium	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
33	Manganese	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
34	Molybdenum	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
35	Phosphorus[16,28] mg	R	100	100	85	55	58	54	54	28	26	25	24
36	Potassium	R	R	R	R	R	R	R	R	R	R	R	R
37	Silicon												
38	Sodium[16]	R	R	R	R	R	R	R	R	R	R	R	R
39	Sulfur	R	R	R	R	R	R	R	R	R	R	R	R
40	Zinc	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?

/1/ No allowance data available for age 0-1 mo When human milk (table 67 p.111) is the source of all nutrients, the constituents in 150 ml furnish an acceptable set of values for columns B, C with notably lower allowances for protein (2+g) calciferol (0 02 µg) niacin (0 31 mg) pyridoxine (20 µg) thiamine (29 µg) calcium (59 mg) and iron (0 27 mg) /2/ Calorie allowance = 1 2 x age 25 values for boys, 1 05 x for girls (cf preceding table) /3/ Allow 1 ml per kilocalorie. /4/ Calorie-correlated. /5/ Kilocalories net utilizable for heat, total activity and growth = either 4.1P + 4 1C + 9 3F, or 4 OP + 4 OC + 9 OF where PCF represent grams of protein carbohydrate and fat and the subscripts i = ingested and a = virtually absorbed (i e , ingested PCF minus fecal PCF) The coefficient 4 1 for P_a allows for loss of 22% of P_a Calories in the urine (urea etc) /6/ 3A = sum of 5A, 6A 7A. Residue = lost in feces, = 8% of 5A + 5% of 6A + 5% of 7A = approximately 3-4% of 3A. /7/ Correlated with body weight /8/ Allow 2 to 3 g if human milk protein or if protein from other source has been effectively treated to increase digestibility /9/ Calculated by: 2A minus Calorie value of 5A and 7a the remainder divided by 4 (cf Fn 5) /10/ Taken as 30-35% of 2A, divided by 9 (cf Fn 5) /12/ Average diet assumed to contain 11% by weight of preformed A (0 3 µg A alcohol = one I U) and 89% of β-carotene (0 6 µg = I U) 0 54 µg of this mixture = one I U Allow per person: 1500 I U of this mixture up to age 1 yr 2000 I U , through age 3 yr, 2500 I U through age 6 3500 I U , through age 9, 4500 I U , through age 12 5000 I U thereafter If dietary carotene is only 50% utilized (as is assumed) the mixture has an effective activity of 0 9 µg = one I U If diet contains only preformed A, allow 0 33 x value in table; if only β-carotene, allow 1 5x /13/ Assumed to be all preformed A alcohol (the values given represent µg of A alcohol: 54 µg equivalent to 180 I U , and 33.8 µg equivalent to 113 I U ; these in turn are equivalent to 300 I U and 187 I U mixed A alcohol and carotene) /14/ Some synthesis by intestinal flora /15/ Generic term for cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity /16/ Neither weight nor calorie-correlated? /17/ Allow 400 I U /person (0 025 µg calciferol = one I U) /18/ Generic term for alpha-, beta-, delta- and gamma-tocopherols /19/ "Folic acid", generic term for pteroylglutamic acid (PGA; folacin) and pteroylglutamates Also known as vitamin M, Bc; L. casei factor Norite eluate factor A daily dietary intake of less than 1 mg/person will probably cover any nutritional need. /20/ The anti hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione; 2-methyl 1,4-naphthoquinone), and vitamin K_2 (2-methyl 3-difarnesyl 1,4-naphthoquinone) Give newborn infant single dose of 1 mg if supplementary K was not given antepartum to mother /21/ Generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide) pellagra preventive (P P) factor Some formation from tryptophan. Allow 10 x 24A. /22/ Requirement practically certain but not demonstrated. Component of Coenzyme A. Good diet supplies approximately 4 mg per 1000 Cal. /23/ Includes pyridoxine, pyridoxal and pyridoxamine Allowance tentatively 2 mg/person? (=adult allowance) /24/ Allow 25µg/g of protein. /25/ Allow 0 5 µg/Calorie /26/ Required only as cobalamin? /27/ Values given are probable requirement greater in adolescence? /28/ Allow 1 0 x 25A.

33 DAILY NUTRIENT ALLOWANCES CAT

Values were derived from a basal diet composed of 40-50 percent meat products (lungs spleen, hearts kidneys beef tongue gullets) with the remainder a mixture of soybean flour skim milk powder bone flour and tomato puree A failure of female cats to give birth to healthy viable young, and/or to lactate occurs on this diet The deficiency is overcome by supplementary feedings of fresh beef or liver or whole milk. The final body weight is greater in cats fed raw (unprocessed) mixtures than in those fed the processed form.

	Specifications / Nutrients per kg body weight per day	Growth		Maintenance	
		Raw Feed	Canned Feed	Raw Feed	Canned Feed
	(A)	(B)	(C)	(D)	(E)
1	Water				
2	Calories metabolizable	123	103	76	67
3	Total feed				
4	Residual[1], g	0 6	0 5	0 38	0 43
5	Protein g	11 7	9 8	7 25	6.3
6	Carbohydrate g	11.7	9 8	7 25	6.3
7	Fat g	3 2	2 7	2	2.3
8	"Essential fatty acids				
9	Vitamin A calc as β-carotene[2] μg	81	67 2	49 8	57
10	Ascorbic acid				
11	Biotin				
12	Choline				
13	Cobalamin[3]				
14	Vitamin D calc as calciferol[4] μg	0 48	0 4	0.29	0.33
15	Vitamin E[5]				
16	Folic acid group[6]				
17	Inositol				
18	Vitamin K[7]				
19	Niacin[8] mg	2.3	2	1.4	1 6
20	Pantothenic acid				
21	Para-aminobenzoic acid				
22	Pyridoxine group[9]				
23	Riboflavine mg	0 32	0.26	0 19	0 22
24	Thiamine, mg	0 05	0 04	0 03	0 04
25	Calcium, g	0 63	0 53	0.39	0 44
26	Chlorine				
27	Cobalt				
28	Copper				
29	Fluorine				
30	Iodine				
31	Iron				
32	Magnesium				
33	Manganese				
34	Phosphorus g	0 4	0 33	0.24	0.28
35	Potassium				
36	Silicon				
37	Sodium				
38	Sulfur				
39	Zinc				

/1/ Fibre /2/ 0 6 μg β-carotene one I U /3/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /4/ 0 025 μg calciferol one I U /5/ A generic term for alpha- beta- delta and gamma-tocopherols /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c factor U L. casei factor Norite eluate factor /7/ The anti-hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1,4-naphthoquinone) synthetic vitamin K (menadione 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1,4-naphthoquinone) /8/ The term is used here as a generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti blacktongue factor /9/ Includes pyridoxine pyridoxal, and pyridoxamine

DAILY NUTRIENT ALLOWANCES: BEEF CATTLE

Values in this table are approximations t adequate allowances intended to provide saf margin above minimum requirements where known. Presentation of values in terms of pe kg body weight per day is for purposes of comparison of species, and does not necessarily imply a less correlation between nutrient need and body weight within the speci . For diets that supply these nutrient allowances, see tabl 50, Diets: Laboratory and Domestic Animal .

Required (R)

	Specifications / Nutrient per kg body weight per day	Young[1] ♂♀150 kg For Growth	Half-grown ♂♀275 kg For Growth	Mature ♀700 kg For Maintenance	Mature ♀700 kg During Pregnancy	Mature ♀700 kg During Lactation[2]	Mature ♂800 kg For Maintenance[3]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Water ml			60[4]	70[5]	70[5]	47[5]
2	Calories[6] metabolizable	71	56	33	33	51	38
3	Total feed[7] g	30	26	16	16	25	13
4	Residue						
5	Protein[8] g	2 5	1.5	0 7	0 7	1 3	0 8
6	Carbohydrate						
7	Fat						
8	Essential fatty acids						
9	Vitamin A[9] cal as β-carotene μg	0.15	0 15	0.13	0 13	0.60	0.13
10	Ascorbic acid						
11	Biotin[10]	R[11]					
12	Choline	R					
13	Cobalamin[12]	R[11]					
14	Vitamin D[13] calc as calciferol μg	0.17[14]					
15	Vitamin E[15]	R	R	R	R	R	R
16	Folic acid group[16]						
17	Inositol						
18	Vitamin K[10 17]	R[11]?					
19	Niacin[10 18]						

	Specifications / Nutrient per kg body weight per day	Young[1] ♂♀150 kg For Growth	Half-grown ♂♀275 kg For Growth	Mature ♀700 kg For Maintenance	Mature ♀700 kg During Pregnancy	Mature ♀700 kg During Lactation[2]	Mature ♂800 kg For Maintenance
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
20	Pantothenic acid[10]	R[11]					
21	Para-aminobenzoic acid						
22	Pyridoxine group[10 19]	R[11]					
23	Riboflavin[10 20] μg	27[11]					
24	Thiamine[10]	R[11]					
25	Calcium mg	110	65	32	32	60	22
26	Chlorine mg	28[21]	18[21]	30[22]	30[22]	30[23]	30[22]
27	Cobalt[24 25] μg	R	R	R	R	R	R
28	Copper	R	R	R	R	R	R
29	Fluorine						
30	Iodine	R	R	R	R	R	R
31	Iron	R	R	R	R	R	R
32	Magnesium mg	13[26]	13[26]	R	R	R	R
33	Manganese[27] mg	0.50	0 32	0 32	0.32	0 50	0 30
34	Phosphorus mg	85	54	32	30	50	22
35	Potassium	R	R	R	R	R	R
36	Silicon						
37	Sodium mg	28[21]	18[21]	20[22]	20[22]	20[23]	20[22]
38	Sulfur[28]	R	R	R	R	R	R
39	Zinc	R	R	R	R	R	R

/1/ 30-35% mature weight /2/ First 3-4 months after parturition. /3/ Moderate activity /4/ 8 gal water daily /5/ 10 gal water daily /6/ Kilocalories These values represent the approximat amount of food energy actually availabl to and capable of use by the animal from food absorbed. If P C and F represent protei carbohydrate and fat ingested P,C,F fecal P,C,F virtually absorbed P C,F Grams of virtually absorbed Px4 Cx4 Fx9 metabolizabl Calories These values are approximate only The value for protein (x4) allows for 30% los of virtually absorbed Calories in the urine (urea, hippuric acid et) In animal husbandry, and in this table metabolizable Calorie are calcul ted from T D.N ("total digestible nutrients") by multiplying grams T D. N by 4 /7/ Air-dried (90% dry weight) /8/ Digestible /9/ 0 6 μg β-carotene one I U /10/ Synthesized by ruminal bacteria. /11/ Young calves require thi vitamin until ruminal function i established t 1-4 months of age /12/ A generic term including cyanocobalamin (vitamin B_{12}) and it hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /13/ 0 025 μg calciferol one I U. Adequate vitami D i normally supplied by exposure of animals to direct sunlight or by ingestion of sun-dried roughages /14/ Based on 300 I U per 100 lb body weight per day /15/ A generic term for alpha- beta- delta- and gamma-tocopherol /16/ Folic acid is not chemical entity but generic term for pteroylglutami acid (folacin), vitami M, vitamin B_c, factor U L. casei factor Norite eluate factor /17/ The anti-hemorrhagic factor A generic term for vitami K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) syntheti vitamin K (menadione 2-methyl 1,4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl-1 4-naphthoquinone) /18/ The term i used here as a generic term for nicotinic acid (niacin) nicotini acid amide (nicotinamide); also for pellagra preventive (P P) factor and blacktongue factor /19/ Includes pyridoxine pyridoxal and pyridoxamine /20/ Based on allowance of approximately 1 microgram pe gram of dry matter consumed. /21/ Based on growing animal requirement of 1 5 g NaCl and less than 5 g Cl per animal per day /22/ Based on consumption of 1 75 lb NaCl per month common on range or pasture /23/ Based on 11 g Na and 15 g Cl as sufficient per animal per day for cow producing 2 gal milk daily /24/ Based on 0.1 mg per 100 lb body weight pe day /25/ Cobalt is probably required in the diet only as cobalamin. /26/ Based on 0 6 g magnesium per 100 lb body weight per day /27/ Estimate on basi of 20 ppm of the ration. /28/ Sulfur is required in the diet only as methionine or as methionine plus cystine

35 DAILY NUTRIENT ALLOWANCES DAIRY CATTLE

Values are approximations to adequate allowances intended to provide safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply close correlation between nutrient need and body weight within the species. For diets that supply these nutrient allowances see table 50 Diets Laboratory and Domestic Animals

Required (R); Not required (N)

	Nutrients per kg body weight per day / Specifications	Young ±68 kg For Growth[1]	Half-grown ±273 kg For Growth[1]	Mature ±545 kg For Maintenance	Mature ±545 kg During Pregnancy[2]	Mature ±545 kg During Lactation[3]	Mature ±900 kg For Maintenance
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Water ml	R[4]	R[4]	80[5]	100[6]	150[7]	R[4]
2	Calories[8], metabolizable	79	50	27	45	66	28
3	Total food[9] g	27	25	15	22	27[10,11]	14
4	Residue						
5	Protein[12] g	2.1	1.4	0.6	1.1	2.1	0.7
6	Carbohydrate						
7	Fat						
8	"Essential" fatty acids						
9	Vitamin A, units as β-carotene[13] mg	0.13	0.13	0.13	0.19	0.19	0.13
10	Ascorbic acid						
11	Biotin	R[14]					
12	Choline	R					
13	Cobalamin[15,16]	R					
14	Vitamin D[17,18], units as calciferol, mg	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]
15	Vitamin E[19]	R	R	R	R	R	R
16	Folic acid group[20]	R					
17	Inositol						
18	Vitamin K[21]	R[14]					
19	Niacin[22]	R					
20	Pantothenic acid	R[14]					
21	Para-aminobenzoic acid						
22	Pyridoxine group[23]	R[14]					
23	Riboflavine mg	30[14]					
24	Thiamine	R[14]					
25	Calcium, mg	110	66	[illegible]	45	95	[illegible]
26	Chlorine mg	R[4]	R[4]	20[24]	R[4]	70[25]	R[4]
27	Cobalt	R	R	R	R	R	R
28	Copper	R	R	R	R	R	R
29	Fluorine						
30	Iodine	R	R	R	R	R	R
31	Iron	R	R	R	R	R	R
32	Magnesium, mg	13[26]	13[26]	R	R	R	R
33	Manganese mg	0.5	0.5	0.3	0.4	0.7	0.3
34	Phosphorus mg	82	55	[illegible]	55	73	[illegible]
35	Potassium	R	R	R	R	R	R
36	Silicon						
37	Sodium, mg	R[4]	R[4]	15[24]	R[4]	49[25]	R[4]
38	Sulfur[27]	R[27]	R[28]	R[28]	R[28]	R[28]	R[28]
39	Zinc						

/1/ 30-50% mature weight. /2/ Late pregnancy. /3/ First 3-4 months after parturition; cow producing 40 lb milk daily (4% fat). /4/ Ad libitum. /5/ Based on 100 lb water daily per cow. /6/ Based on 110 lb water daily per cow. /7/ Based on 4 5 lb water for each lb of milk produced. /8/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. If P C and F represent protein, carbohydrate and fat ingested P C,F fecal P C,F virtually absorbed P C,F. Grams of virtually absorbed P×4 + C×4 + F×9 metabolizable Calories. These values are approximate only. The value for protein (×4) allows for 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry and in this table metabolizable Calories are calculated from "T.D.N." ("total digestible nutrients") by multiplying grams T.D.N. by 4. /9/ Air-dried (90% dry weight). Differences in roughage intake permit wide variation in these values. /10/ This value is based on general experience and is lower than that calculated from the rule to allow 0 64 lb extra feed per lb milk. By this rule, 545 kg cow giving 40 lb milk daily would be allowed 15 g/kg maintenance (column D) plus 21 6 g/kg for lactation, making a total of 37 g/kg. This constitutes larger bulk than the ordinary lactating animal will consume. /11/ 1/4 to 1/3 nutrients would be in form of roughage feeds containing much cellulose. /12/ Digestible. /13/ 0 0006 mg β-carotene one I U. /14/ Young calves require this vitamin until ruminal function is established; this may vary from 1-4 months of age. /15/ A generic term for cyanocobalamin (vitamin B_{12}) and its hydrogenation product (variously known as B_{12a} and B_{12b}) which has approximately the same biological activity. /16/ Not required after one month of age. /17/ Based on 400 I. U. per 100 lb body weight. /18/ 0 025 µg calciferol one I U. /19/ A generic term for alpha- beta- delta- gamma-tocopherols. /20/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, and Norite eluate factor. /21/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione 2-methyl 1,4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1,4-naphthoquinone). /22/ The term is used here as generic term including nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive factor (P P) and anti-blacktongue factor. /23/ Includes pyridoxine, pyridoxal and pyridoxamine. /24/ Based on 2 1 g NaCl/100 lb body weight, plus an additional 3.6 g NaCl per 100 lb body weight for cow producing 40 lb of milk daily. /25/ Based on 2.1 g NaCl/100 lb body weight per day when the principal feeds consist of natural diets (grains and hays) other than milk. /26/ Based on 0.6 g magnesium/100 lb body weight per day. /27/ Very young animals should be supplied sulfur in organic compounds such as S-containing amino acids and the vitamins thiamine and biotin. /28/ After ruminal function is established, elemental sulfur can satisfy the requirement and thiamine and biotin are no longer needed in the diet (cf Fn 14).

36 DAILY NUTRIENT ALLOWANCES DOG

Values are approximations to adequate requirements for normal growth health and productivity Presentation of values in terms of per kg body weight per day" is for purposes of comparison of species and *does not necessarily imply a close correlation between nutrient need and body weight* within the species

	Nutrients per kg body weight per day (Specifications)	Young Growth	Mature Maintenance
	(A)	(B)	(C)
1	Water		
2	Calories[1] metabolizable	150[2]	75[2]
3	Total feed, g	50	25-40
4	*Residue*		
5	Protein[3] g	2 5[4]	3-4[4]
6	Carbohydrate g	26	17 6
7	Fat g	7	1 5
8	"Essential fatty acids		
9	Vitamin A, calc as β-carotene[5] μg	120	59
10	Ascorbic acid		
11	Biotin[6 7]		07
12	Choline mg	55	33
13	Cobalamin[8] μg	1 5	0 55
14	Vitamin D calc as calciferol[9] μg	0 50	0 16
15	Vitamin E[10] mg	2.2[10]	
16	Folic acid group[11] μg	15	8
17	Inositol		0
18	Vitamin K[12]		07
19	Niacin[13] mg	0 4	0.24
20	Pantothenic acid mg	0.1	0 055
21	Para-aminobenzoic acid	0	0
22	*Pyridoxine group*[14] mg	0 055	0 022
23	Riboflavine mg	0 09	0 044
24	Thiamine, mg	0 033	0 018
25	Calcium, mg	330[15]	280[16]
26	Chlorine mg	440[17]	180
27	Cobalt mg	0 05	0 05
28	Copper mg	0 16	0 16
29	Fluorine mg		0 08[18]
30	Iodine mg	0 033	0 033
31	Iron mg	1 3	1 3
32	Magnesium, mg	55	11
33	Manganese mg	0 22	0 11
34	Phosphorus mg	440[19]	220[20]
35	Potassium, mg	330[21]	220
36	Silicon		
37	Sodium, mg	60	120
38	Sulfur mg		7[18]
39	Zinc mg	0.42	0.11

/1/ Kilocalories /2/ There is considerable variation, depending on size of the animal /3/ Complete balanced protein *free of toxic materials* /4/ Recommended *allowance of 20% in di t* /5/ 0 6 μg β-carotene = one I U /6/ Needed only when avidin is in diet /7/ Progressive paralysis cured by daily administration of 100 μg/kg body weight which probably well exceeds daily need of healthy animals /8/ A generic term including *cyanocobalamin* (vitamin B_{12}) *and its hydrogenation* product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /9/ 0 025 μg calciferol = one I U /10/ A generic term for alpha- beta- delta- and gamma-tocopherols A value of 1 has been reported. /11/ *Folic acid is not a chemical entity* but a generic term for pteroylglutamic acid (folacin) vitamin M, vitamin B_c, factor U L casei factor Norite eluate factor Values are based on the requirement of the fox /12/ The anti hemorrhagic factor A generic term for vitamin K_1 (2 methyl 3-phytyl-1,4-naphthoquinone) *synthetic vitamin K* (*menadione* = 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2 methyl 3-difarnesyl-1 4-naphthoquinone) Required when normal bile production is impaired /13/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); *also for pellagra preventive* (P.P) *factor* anti blacktongue factor /14/ Includes pyridoxine pyridoxal and pyridoxamine /15/ A value of 90 has been reported. /16/ A value of 45 has been reported /17/ A value of 90 has been reported. /18/ Calculated from Wesson s salt mixture (0 7 g salt mixture/kg *body weight per day*) /19/ A *value of* 75 has been reported. /20/ A value of 35 has been reported. /21/ A value of 150 has been reported

37 DAILY NUTRIENT ALLOWANCES FOX AND MINK

Values are approximations to adequate requirements for normal growth health and productivity Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply close correlation between nutrient need and body weight within the species For diets that supply the allowances in these columns see table 50 Diets Laboratory and Domestic Animals

Specifications / Nutrients per kg body weight per day	Required (R)											
	Fox						Mink					
	Young 11 wk		3/4 grown 23 wk		Mature		Young 11 wk		3/4 grown 23 wk		Mature	
	♂2.3 kg	♀2.0 kg	♂4.7 kg	♀4.1 kg	♂5.7 kg	♀4.7 kg	♂0.59 kg	♀0.45 kg	♂0.95 kg	♀0.68 kg	♂1.04 kg	♀0.68 kg
	Growth				Maintenance		Growth				Maintenance	
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
1 Water												
2 Calories[1] metabolizable					128[2]	127[2]					271[3]	263[3]
3 Total feed dry[4] g	73	62	42	37	25	27	100	111	86	100	63	100
4 Residue												
5 Protein g	18	15	8	9	5	6	22	24	14	16	13	16
6 Carbohydrate[5]	R	R	R	R	R	R	R	R	R	R	R	R
7 Fat[6]												
8 "Essential" fatty acids												
9 Vitamin A, also as β-carotene[7] mg	0.08	0.06	0.04	0.04	0.03	0.03	0.10	0.11	0.09	0.10	0.08	0.10
10 Ascorbic acid												
11 Biotin												
12 Choline												
13 Cobalamin[8]												
14 Vitamin D	R	R	R	R	R	R	R	R	R	R	R	R
15 Vitamin E[9]												
16 Folic acid group[10] mg	0.014	0.012	0.008	0.007	0.005	0.005	0.020	0.022	0.017	0.021	0.015	0.021
17 Inositol												
18 Vitamin K[11]												
19 Niacin[12] mg	0.74	0.63	0.40	0.36	0.26	0.26	0.98	1.11	0.87	1.0	0.78	1.0
20 Pantothenic acid	0.56	0.50	0.32	0.29	0.21	0.19	0.80	0.89	0.68	0.79	0.65	0.79
21 Para-aminobenzoic acid												
22 Pyridoxine group[13] mg	0.08	0.07	0.05	0.04	0.03	0.03	0.10	0.13	0.09	0.12	0.09	0.12
23 Riboflavin mg	0.14	0.12	0.08	0.07	0.05	0.05	0.20	0.22	0.17	0.21	0.15	0.21
24 Thiamine, mg	0.08	0.07	0.05	0.04	0.03	0.03	0.10	0.13	0.09	0.12	0.09	0.12
25 Calcium g	0.43	0.36	0.26	0.21	0.16	0.15	0.39	0.40	0.34	0.40	0.35	0.40
26 Chlorine[14]	R	R	R	R	R	R	R	R	R	R	R	R
27 Cobalt												
28 Copper												
29 Fluorine												
30 Iodine												
31 Iron												
32 Magnesium												
33 Manganese												
34 Phosphorus g	0.43	0.36	0.26	0.21	0.16	0.15	0.39	0.40	0.34	0.40	0.35	0.40
35 Potassium												
36 Silicon												
37 Sodium[15]	R	R	R	R	R	R	R	R	R	R	R	R
38 Sulfur												
39 Zinc												

/1/ Kilocalories /2/ Based on 55 Cal/lb body weight /3/ Based on 124 Cal/lb body weight /4/ Usual wet ration assumed to be 34% dry weight /5/ Foxes and minks have been maintained satisfactorily on purified basal diet containing 66% sucrose /6/ Fresh fat can be used in the diet to the extent of 5 10% /7/ 0.0006 mg β-carotene one I U /8/ A generic term including cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a} or B_{12b}) which has approximately the same biological activity /9/ A generic term for alpha beta- gamma- and delta-tocopherols /10/ Folic acid is generic term for pteroylglutamic acid (folacin) and pteroylglutamates Also known as vitamin M, vitamin B_c factor U L. casei factor Norite eluate factor /11/ The anti-hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1 4-naphthoquinone) /12/ Generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti-blacktongue factor /13/ Includes pyridoxine pyridoxal and pyridoxamine /14/ 0 5% NaCl added to dry diet

38 DAILY NUTRIENT ALLOWANCES HORSE

Values are approximations to adequate allowances intended to provide safe margins above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply linear correlation between nutrient need and body weight within the species.

Required (R); Requirement questionable (?)

Nutrient per kg body weight per day \ Specifications	Young	Half grown	Mature			Mature	
	♂♀182 kg	♂♀375 kg	♂♀635 kg			♀635 kg	
	Growth		Maintenance	Medium Work	Hard Work	Pregnancy, Light Work	Lactation, Light Work
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1 Water							
2 Calories[1] metabolizable	69	47	29	43	54	39	64
3 Total feed[2] g	30	22	13	19	25	17	25
4 [illegible]							
5 Protein[3] g	2.9	1.3	0.6	0.8	1.0	0.8	1.9
6 Carbohydrate[3] g	12.9	10.1	6.0	9.1	11.5	8.2	12.9
7 Fat[3] g	0.6	0.4	0.3	0.4	0.5	0.4	0.6
8 "Essential" fatty acids							
9 Vitamin A, calc. as β-carotene[4] mg	0.11	0.11	0.11	0.11	0.11	0.13	0.13
10 Ascorbic acid							
11 Biotin[5]	R	R	R	R	R	R	R
12 Choline							
13 Cobalamin[6]							
14 Vitamin D, calc. as calciferol[7] µg	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15 Vitamin E[8]							
16 Folic acid group[9]	R	R	R	R	R	R	R
17 Inositol							
18 Vitamin K[10]							
19 Niacin[11] mg	0.10	0.10	0.10	0.10	0.10	0.13	0.13
20 Pantothenic acid[5]	R?	R?	R?	R?	R?	R?	R?
21 Para-aminobenzoic acid							
22 Pyridoxine group[12]	R	R	R	R	R	R	R
23 Riboflavin[5]	R	R	R	R	R	R	R
24 Thiamine[5]	R	R	R	R	R	R	R
25 Calcium, mg	113	55	20	20	52	31	60
26 Chlorine	R	R	R	R	R	R	R
27 Cobalt	?	?	?	?	?	?	?
28 Copper	?	?	?	?	?	?	?
29 Fluorine							
30 Iodine	R	R	R	R	R	R	R
31 Iron							
32 Magnesium	R	R	R	R	R	R	R
33 Manganese							
34 Phosphorus mg	96	51	[illegible]	31	36	40	30
35 Potassium							
36 Silicon							
37 Sodium	R	R	R	R	R	R	R
38 Sulfur							
39 Zinc							

/1/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. If P, C and F represent protein, carbohydrate and fat: ingested P,C,F − fecal P,C,F = virtually absorbed P,C,F. Grams of virtually absorbed (P×4 + C×4 + F×9) = metabolizable Calories. These values are approximate only. The value for protein (×4) allows for 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry and in this table metabolizable Calories are calculated from "T.D.N." ("total digestible nutrients") by multiplying grams T.D.N. by 4. /2/ Air-dried (90% dry weight). /3/ Digestible. /4/ 0.0006 mg β-carotene = one I.U. /5/ Probably synthesized by the horse. /6/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /7/ 0.025 µg calciferol = one I.U. Normally supplied by exposure to direct sunlight or by ingestion of sun-dried roughages. /8/ A generic term for alpha-, beta-, delta- and gamma-tocopherols. /9/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /10/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl 3-phytyl 1,4-naphthoquinone), synthetic vitamin K (menadione, 2-methyl 1,4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1,4-naphthoquinone). /11/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide); also for pellagra preventive (P.P.) factor, anti-blacktongue factor. /12/ Includes pyridoxine, pyridoxal and pyridoxamine.

39 DAILY NUTRIENT ALLOWANCES MONKEY

Values are for Macaca mulatta They are approximations to adequate allowances and are applicable to juvenile or adolescent as well as mature monkeys The presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight within the species

Required (R)

No.	Nutrients per kg body weight per day / Specifications (A)	Rhesus Monkey, Growth and Maintenance: Minimum Requirement (B)	Rhesus Monkey, Growth and Maintenance: Daily Allowance[1] (C)
1	Water		
2	Calories[2] metabolizable	41 54[3]	158[3]
3	Total feed g		40
4	Residue		
5	Protein g		7 2
6	Carbohydrate g		28 4
7	Fat g	1 6-2 0	
8	Essential fatty acids		?
9	Vitamin A calc as β carotene[4] μg	R	56
10	Ascorbic acid mg	1	4
11	Biotin μg	5	8
12	Choline mg		405
13	Cobalamin[6] μg		?
14	Vitamin D calc. as calciferol[7] μg	R	0 32
15	Vitamin E[8] mg	R	2.0
16	Folic acid group[9,10]	μg 35-50	80
17	Inositol mg		40
18	Vitamin K[11] μg		40
19	Niacin[12,13] mg	2 3[14]	1 0
20	Pantothenic acid[15] mg	<1	0 8
21	Para-aminobenzoic acid mg		12 0
22	Pyridoxine group[15,16] μg	400[14]	140
23	Riboflavine[15] μg	25-30	140
24	Thiamine μg	15	140
25	Calcium mg	<60	155
26	Chlorine mg		250
27	Cobalt[17] μg		19
28	Copper μg		480
29	Fluorine μg		40
30	Iodine mg		0 6
31	Iron mg		5
32	Magnesium mg		10
33	Manganese mg		1 6
34	Phosphorus mg		170
35	Potassium mg		135
36	Silicon		?
37	Sodium mg		130
38	Sulfur mg		14
39	Zinc mg		0 9

/1/ For a diet that will supply the nutrients in this column see table 50 Diets: Laboratory and Domestic Animals /2/ Kilocalories These values represent the approximate amount of food energy available to and capable of use by the animal from the food absorbed /3/ For the adolescent monkey /4/ 0 6 μg β-carotene = one I U /5/ 25 mg has been used with satisfactory results /6/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /7/ 0 025 μg calciferol = one I U /8/ A generic term for alpha beta delta gamma tocopherols /9/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c factor U L. casei factor Norite eluate factor /10/ Increase in allowance above the minimum value has not produced any beneficial effects except in deficiencies of pantothenic acid pyridoxine and riboflavine or when the animal has first been depleted of folacin /11/ A generic term for vitamin K_1 (2 methyl 3-phytyl 1 4-naphthoquinone) vitamin K_2 (2-methyl 3-difarnesyl 1 4-naphthoquinone) and synthetic vitamin K (menadione = 2-methyl 1 4-naphthoquinone) /12/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti black tongue factor /13/ Requirement depends somewhat on tryptophan content of the diet /14/ Value derived from repletion (therapeutic) type experiment. /15/ Exact requirement difficult to determine since a deficiency of the vitamin elicits a requirement for an unidentified factor the "monkey anti anemia factor" or greatly increases requirement for folacin /16/ Includes pyridoxine pyridoxal and pyridoxamine /17/ Need except as cobalamin not known

40 DAILY NUTRIENT ALLOWANCES RAT

Values are approximations to adequate allowances intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between species and does not necessarily imply close correlation between nutrient need and body weight within the species

Required (R); Not required (R̸)

Specifications / Nutrients per kg body weight per day	White Rat				
	Young	Half-grown	Mature		
	♂29 da	♂51 da; ♀59 da	♂108 da; ♀120 da		
	♂♀0.05 kg	♂♀0.15 kg	♂0.30 kg; ♀0.20 kg	♀0.30 kg	♀0.30 kg
	Growth		Maintenance	Pregnancy	Lactation
(A)	(B)	(C)	(D)	(E)	(F)
1 Water	R	R	R	R	R
2 Calories metabolizable	♂290; ♀280	♂195; ♀180	♂113; ♀135	R	R
3 Total food g	100	75	50		
4 Residue	R̸	R̸	R̸	R̸	R̸
5 Protein g	R	19	R	R	R
6 Carbohydrate	R̸	R̸	R̸	R̸	R̸
7 Fat[1]	R̸	R̸	R̸	R̸	R̸
8 "Essential" fatty acids	R	R	R	R	R
9 Vitamin A[2] or as β-carotene mg	0.013[3]	0.013[3]	0.013[3]	R	R
10 Ascorbic acid	R̸	R̸	R̸	R̸	R̸
11 Biotin	R̸	R̸	R̸	R̸	R̸
12 Choline, mg	80[3]	40[3]	40[3]	50	60
13 Cobalamin[4]	R	R?	R?	R?	R
14 Vitamin D	R̸	R̸	R̸	R̸	R̸
15 Vitamin E mg	5.0[3]	1.8[3]	1.8[3]	1.5	1.5
16 Folic acid group[5]	R̸[6]	R̸[6]	R̸[6]	R̸[6]	R̸[6]
17 Inositol	R̸[7]	R̸[7]	R̸[7]	R̸[7]	R̸[7]
18 Vitamin K[8]	R̸	R̸	R̸	R̸	R̸
19 Niacin[9]	R̸	R̸	R̸	R̸	R̸
20 Pantothenic acid mg	1.0	0.50	0.36	0.45	0.45
21 Para-aminobenzoic acid	R̸	R̸	R̸	R	R
22 Pyridoxine group[10] mg	0.30	0.35	0.043[3]	0.09	0.07
23 Riboflavin mg	0.30	0.27	0.13[3]	0.06	0.08
24 Thiamine mg	0.2	0.05	0.053[3]	0.05	0.05
25 Calcium g	0.8–1.0	0.25–0.55	0.16–0.2	0.16–0.2	0.16–0.2
26 Chlorine mg	100	50	20	20	20
27 Cobalt[11] µg	R̸	R̸	R̸	R̸	R̸
28 Copper mg	2	1	1	2	2
29 Fluorine	R̸?	R̸?	R̸?	R̸?	R̸?
30 Iodine mg	0.006	0.006	0.008	0.008	0.008
31 Iron mg	5	5	5	20	20
32 Magnesium, mg	5	5	5	5	5
33 Manganese mg	10	7	2	5	5
34 Phosphorus g	0.7–0.9	0.25–0.5	0.14–0.18	0.14–0.18	0.14–0.18
35 Potassium, mg	♂300; ♀160	♂80; ♀50	60	60	200
36 Silicon	R̸	R̸	R̸	R̸	R̸
37 Sodium, g	0.5	0.5	0.2	0.2	0.2
38 Sulfur[12]	R	R	R	R	R
39 Zinc mg	0.8	0.55	R	R	R

/1/ There is no evidence that fat per se is needed except as means of supplying essential fatty acids. /2/ 0.0006 mg β-carotene = one I. U. /3/ Values raised 20% to provide margin above minimum requirements submitted by Brown, R. A. /4/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /5/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /6/ Essential when sulfa drugs are administered or when diet is low in protein. /7/ Some authorities claim requirement is indicated. /8/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl 3-phytyl 1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl 1,4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1,4-naphthoquinone). /9/ A generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-black-tongue factor. /10/ Includes pyridoxine, pyridoxal and pyridoxamine. /11/ The cobalt present in vitamin B_{12} takes care of the entire cobalt requirement of the rat as far as is known; inorganic cobalt is not utilized nor required. /12/ Organic sulfur (methionine) satisfies all the sulfur requirements; inorganic sulfur is not required.

41 DAILY NUTRIENT ALLOWANCES GERM-FREE RAT CHICKEN

The allowances in this table are based on diets demonstrated to be adequate for and, in some cases definitely in excess of the needs of the animal. All elements in the diet were steam sterilized (30 min. 121°C) Sterility of environment was maintained in the case of the germ-free[1] animals All other conditions were identical for both the germ-free and control animals

	Specifications / Nutrients per kg body weight per day	Chicken[2]		Rat White			
		Bantam	White Leghorn	Young		Young Adult[3]	
		28 da	28 da	10 da			
		♂♀0.11 kg	♂♀0.25 kg	♂♀0.02 kg[4,5]	♂♀0.01 kg[6]	♂♀0.20 kg	
		Controls and Germ-free		Controls	Germ-free	Controls	Germ-free
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Water ml	200	180	400	550	90	110
2	Calories[7] metabolizable	580	550	520	1200	190	190
3	Total food, g	140	80	100	150	50	50
4	Residue, g		5	0	0	0	2
5	Protein, g	48	28	48	43	13	13
6	Carbohydrate g	65	40	16	15	27	27
7	Fat g	11	5	50	100	3	3
8	"Essential" fatty acids						
9	Vitamin A[8] calc as β-carotene μg	320	190	1.2	12	240	240
10	Ascorbic acid, mg	270	160	3 5	25		50?
11	Biotin, μg	55	32	42	40	50	50
12	Choline mg	270	160		50	4	4
13	Cyanocobalamin[9] g						
14	Vitamin D, μg	1.2[10]	0.6[10]	0 07[11]	11[11]	1[11]	1[11]
15	Vitamin E[12] mg	55	20			25	25
16	Folacin[13] mg	1.4	0.8	0 16	0 58	0.4	0.4
17	Inositol, mg	140	80			50	50
18	Vitamin K[14] mg	7	4			5	5
19	Nicotinamide mg	7	4	9	2 5	5	5
20	Pantothenic acid[15] mg	27	16	2 5	12	12	12
21	Para-aminobenzoic acid						
22	Pyridoxine mg	3	1.6	0 5	5	1.4	1.4
23	Riboflavin mg	4	2.4	0 01	6	1 3	1.3
24	Thiamine, mg	8	5	4	5	0.4	0.4
25	Calcium, g	1 1	0 65	1.0	1 3	0.41	0.41
26	Chlorine mg	240	140			90	90
27	Cobalt mg	1	0.6			0 3	0 3
28	Copper mg	8	5		1.5	5	5
29	Fluorine mg	1	0.6			0 3	0 3
30	Iodine mg	2	1			0.8	0.8
31	Iron, mg	80	50	3 5	25	25	25
32	Magnesium, mg	60	55	150	80	20	20
33	Manganese mg	25	14		0 05	9	9
34	Phosphorus g	1.1	0.63	1.0	0.8	0.4	0.4
35	Potassium, g	0.8	0 5	0 5	0 7	0 5	0 5
36	Silicon						
37	Sodium, g	0 7	0.4	0.4	0 5	0.25	0.25
38	Sulfur mg					0 7	0 7
39	Zinc mg	1.6	0 9				

/1/ A discussion of the meaning of germ-free and a description of the methods used in raising germ-free animals will be found in the Lobund reports of the University of Notre Dame /2/ It should be noted that each of these columns (B and C) contains data for both control and germ-free chickens No difference was found between the daily nutrient allowances of controls and germ-free chickens in the case of the two breeds bantam and white leghorn. For diet that will supply the nutrients listed in these columns see table 50, Diets Laboratory and Domestic Animals /3/ Nutrient allowances for growth, maintenance reproduction. /4/ Suckling rats /5/ The values in this column are based on the chemical composition of normal rat milk. /6/ Artificially fed. /7/ Kilocalories calculated from the following standards protein 4.2 calories per gram; carbohydrate 4.13 calories per gram; and fat 9.4 calories per gram. /8/ One I U 0.6 μg β-carotene /9/ Vitamin B_{12} /10/ Calculated as D_3 One International Chick Unit 1 35 A.O.A.C units 0.025 μg vitamin D_3 (7-dehydrocholesterol) /11/ Calculated as calciferol. One I U 0.025 μg calciferol. /12/ As α-tocopherol. /13/ Folic acid; pteroylglutamic acid. /14/ As menadione 2-methyl-1, 4-naphthoquinone /15/ As calcium pantothenate

DAILY NUTRIENT ALLOWANCES CERTAIN RODENTS

Values are approximations to adequate allowances intended to provide a safe margin above minimum requirements where known Presentation of values in terms of per kg body weight per day" is for purposes of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight within the species

Required (R); Not required (R̸)

	Specifications / Nutrients per kg body weight per day	Cotton Rat	Hamster	Mouse
		Young		
		0 025 kg	0 025 kg	0 025 kg
		Growth		
	(A)	(B)	(C)	(D)
1	Water ml	R	R	182
2	Calories utilizable[1]	620	645	657
3	Total feed g	150	150	140
4	Residue g		4 8[2]	
5	Protein g	58[3]	52[3]	42[3]
6	Carbohydrate g	100[4]	104[5]	70
7	Fat g	7 5[6]	11 2[7]	21
8	Essential[8] fatty acids g			0 14
9	Vitamin A calc as β-carotene[8] mg	0 9[9]	1 1[10]	0 84[11]
10	Ascorbic acid	R̸	R̸	R̸
11	Biotin mg	0 02	0 02	0 05[12]
12	Choline mg	160	640	210
13	Cobalamin[13] mg		R̸[11]	4[14]
14	Vitamin D calc as calciferol[15] μg	59	6 8[10]	3 3[11]
15	Vitamin E[16] mg		4 0	7[11]
16	Folic acid group[17] mg	0 32	0 32	0 7
17	Inositol mg	160	400	R̸
18	Vitamin K[18] mg		4 8	1 4[11]
19	Niacin[19,20] mg	4 0	8 0	7
20	Pantothenic acid mg	3 2	1 6[21]	14
21	Para-aminobenzoic acid mg	48	160	R̸
22	Pyridoxine group[22] mg	0 40	1.9	1.4
23	Riboflavine mg	0 48	2.6	2.8
24	Thiamine mg	0 40	1.3	1.4
25	Calcium g			0 9
26	Chlorine mg			800
27	Cobalt μg			400
28	Copper mg			0 7
29	Fluorine mg			0 6
30	Iodine mg			1 3
31	Iron mg			50
32	Magnesium mg			66
33	Manganese mg			3 6
34	Mineral salts g	6 4	6 4	
35	Phosphorus g			0 94
36	Potassium mg			390
37	Silicon			
38	Sodium g			0 32
39	Sulfur			
40	Zinc mg			0 3
41	Unknown factors	R[23]	R[23]	

/1/ Kilocalories These values represent the approximate amount of food energy available to and capable of use from the food absorbed. /2/ Cellulose /3/ Casein. /4/ Sucrose /5/ Glucose /6/ Corn oil. /7/ Lard /8/ 0 0006 mg β-carotene = one I U /9/ As A and D oil (3000 I U A 400 I U D per gram) /10/ As A D oil (1200 I U A, and 170 I U D per gram) /11/ Probably not required in short-term experiments with offspring from well nourished mice /12/ Possibly not required in diets of ordinary composition. /13/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /14/ 0 04 mg = minimum requirement /15/ 0 025 μg calciferol = one I U /16/ A generic term for alpha- beta- delta- and gamma-tocopherols /17/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c factor U L. casei factor Norite eluate factor /18/ The anti-hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione = 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1 4-naphthoquinone) /19/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti-blacktongue factor /20/ Response to nicotinamide inversely proportional to tryptophan content of diet /21/ As calcium pantothenate /22/ Includes pyridoxine pyridoxal pyridoxamine /23/ 1:20 liver extract

43 DAILY NUTRIENT ALLOWANCES SHEEP

Values are approximations to adequate allowances intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply close correlation between nutrient need and body weight within the species. For diets that supply these nutrient allowances see table 50 Diets Laboratory and Domestic Animals

	Specifications	Young	Half-grown	Mature			
		♂85 kg	♂76 kg	♀79 kg			♂79 kg
	Nutrients per kg body weight per day	Growth		Maintenance	Pregnancy	Lactation	Maintenance
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Water	60	50	62	62	98	69
2	Calories[1] metabolizable	95	101	60	70	85	60
3	Total feed[2] g	41	43	29	32	37	26
4	Residue						
5	Protein[3] g	3.4	2.9	1.6	1.8	2.3	1.3
6	Carbohydrate	21	22	14	16	19	12
7	Fat	0.65	0.62	0.39	0.50	0.65	0.33
8	"Essential" fatty acids						
9	Vitamin A, calc. as β-carotene mg	0.13	0.12	0.12	0.13	0.14	0.12
10	Ascorbic acid						
11	Biotin						
12	Choline						
13	Cobalamin[5] µg			1.7	1.7	1.7	
14	Vitamin D calc. as calciferol[6] µg	0.2	0.2	0.2	0.2	0.2	0.2
15	Vitamin E[7] mg	0.3	0.3	0.3	0.3	0.3	0.3
16	Folic acid group[8]						
17	Inositol						
18	Vitamin K[9]						
19	Niacin[10]						
20	Pantothenic acid[11]	R					
21	Para-aminobenzoic acid						
22	Pyridoxine group[12]	R					
23	Riboflavin[11]	R					
24	Thiamine[11]	R					
25	Calcium, mg	110	94	58	73	110	50
26	Chlorine mg	150[12]	150[12]	150[12]	150[12]	150[12]	150[12]
27	Cobalt mg	0.002	0.002	0.002[13]	0.002[13]	0.002[13]	0.001[13]
28	Copper mg	0.2	0.2	0.2[14]	0.2[14]	0.2[14]	0.2[14]
29	Fluorine						
30	Iodine mg				0.02[15]		
31	Iron	R	R	R	R	R	R
32	Magnesium						
33	Manganese						
34	Phosphorus mg	90	82	5	60	80	40
35	Potassium						
36	Silicon						
37	Sodium, mg	100[12]	100[12]	100[12]	100[12]	100[12]	100[12]
38	Sulfur						
39	Zinc						

/1/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. If P, C and F represent protein, carbohydrate and fat ingested P,C,F – fecal P,C,F = virtually absorbed P,C,F. Grams of virtually absorbed P×4 + C×4 + F×9 = metabolizable Calories. These values are approximate only. The value for protein (×4) allows for 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry and in this table metabolizable Calories are calculated from "T. D. N." ("total digestible nutrients") by multiplying grams T.D.N. by 4. /2/ Air-dried (90% dry weight). /3/ Digestible. /4/ 0.0006 mg β-carotene = one I. U. /5/ A generic term including cyanocobalamin and its hydrogenation product (known variously as B_{12b} or B_{12a}) which has approximately the same biological activity. /6/ 0.025 µg calciferol = one I. U. /7/ A generic term for alpha-, beta-, delta- and gamma-tocopherols. May help prevent muscular dystrophy in lambs and may be needed for normal reproduction. /8/ Folic acid is not a chemical entity but generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /9/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione, 2-methyl-1,4-naphthoquinone) and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /10/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /11/ Synthesized by ruminal bacteria, but young lambs may need supplements in diet. /12/ Based on 1 lb/150 lb body weight/month. /13/ Based on about 0.1 mg/adult sheep/day. /14/ Based on 10 mg copper/adult sheep/day. /15/ Recommended during gestation period in form of iodized salt

DAILY NUTRIENT ALLOWANCES SWINE

Values are approximations to adequate requirements for normal growth health and productivity Presentation of values in of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply a close correlation [between] nutrient need and body weight within the species For diets that supply these nutrient allowances see table 50 Laboratory and Domestic Animals

Required (R); Not required (ɍ)

	Nutrients per kg body weight per day / Specifications	Young[1] ♂768 kg Growth	Half grown ♂7113 kg Growth	Mature ♂7227 kg Breeding Pregnancy	Mature ♀205 kg Lactation
		( )	( )		F
1	Water				
2	Calories[2] productible	140	100	45	80
3	Total food[3] g	45	33	15	28
4	Residue				
5	Protein[4] g	5 9	4.0	2.1	3 9
6	Carbohydrate				
7	Fat	R	R	R	R
8	"Essential fatty acids				
9	Vitamin A, calc as β-carotene[5], mg	0 045[5]	0 045[5]	0 09	0.16
10	Ascorbic acid[6]	ɍ	ɍ	ɍ	ɍ
11	Biotin[7]				
12	Choline[8]	R			
13	Cobalamin[9] µg	0 5[10]	R[10]	R[10]	R[10]
14	Vitamin D calc as calciferol[11] µg	0.23	0 17	0 08	0.14
15	Vitamin E[12]	R[13]	R[13]	R[13]	R[13]
16	Folic acid group[14]	R[15]			
17	Inositol				
18	Vitamin K[7,16]				
19	Niacin[17] mg	0 5	0 37	0.17	0 31

	Nutrients per kg body weight per day / Specifications	Young[1] ♂768 kg Growth	Half-grown ♂7113 Growth	Mature ♂7227 Pregnancy	Mature ♀205
	(	(B)	(C)	(D)	(
	Pantothenic acid mg	0.45	0 34	0.15	
	Para-aminobenzoic acid[6]				
	Pyridoxine group[18] mg	<0 11			
23	Riboflavine mg	0.10	0 07	0.04	
24	Thiamine mg	0.05	0 04	0.02	
25	Calcium, mg	250	180	65	190
26	Chlorine[13,19] mg	140	100	40	80
27	Cobalt,				
28	Copper[20]	R	R	R	R
29	Fluorine[6]				
30	Iodine µg	<4	<4	<4	<4
31	Iron	R	R	R	R
32	Magnesium	R	R	R	R
33	Manganese	R	R	R	R
34	Phosphorus mg	150	110	50	90
35	Potassium, mg	50-100	50-100	50-100	
	Silicon[6]				
	Sodium[19] mg	90	65	33	50
	Sulfur[6]				
	Zinc	R	R	R	

/1/ 30-35% mature weight /2/ Kilocalories These values represent the approximate amount of food energy actually available capable of use by the animal from the food absorbed. If P C and F represent protein, carbohydrate and fat ingested P,C F P C,F metabolizable Calories These values are approximate only The value for protein (x4) allows for a 30% loss of virt[ually] absorbed Calories in the urine (urea, hippuric acid, etc) In animal husbandry and in this table metabolizable Calories are c[alcu]lated from "T D N (total digestible nutrients) by multiplying grams T D. N by 4 /3/ Air-dried (90% dry weight) /4/ protein. /5/ 0.0006 mg β-carotene one I U A value of 0 09 mg/kg body weight per day has been suggested for growth of swine Supplement to natural ration not necessary /7/ Synthesized by intestinal flora /8/ Baby pigs require 0.1% choline in diet generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} and B_{12b}) which [ap]proximately the same biological activity /10/ Necessary for growth and reproduction. /11/ 0.025 µg calciferol = one I U /1[2]/ generic term including alpha- beta- delta- and gamma-tocopherols /13/ For proper muscular nutrition /14/ Folic acid is [not a] chemical entity but a generic term for a group of factors including pteroylglutamic acid (folacin) vitamin M, vitamin B_c, L. casei factor and Norite eluate factor /15/ Swine synthesize most if not all they need. /16/ The anti-hemorrhagic factor [gen]eric term including vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone) syntheti[c] vitamin K (menadione and vitamin K_2 (2-methyl-3-difarnesyl 1 4-naphthoquinone) /17/ The term is used here as a generic term including nicotinic [acid] (niacin) and, nicotinic acid amide (niacinamide); also for pellagra preventive (P P) factor; and anti-blacktongue factor The amount may be uncertain since it depends on the protein intake /18/ Includes pyridoxine pyridoxal, and pyridoxamine /19/ In /20/ Copper requirement approximately 5% iron requirement

45 DAILY NUTRIENT ALLOWANCES CHICKEN

Values are approximations to adequate requirements for normal growth, health and productivity. Presentation of values in ter[…] "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply close correlation be[…] nutrient need and body weight within the species. For diets that supply the allowances in these columns, see table 50 D[…] Laboratory and Domestic Animals

	Specifications → Nutrients per kg body weight per day	Single Comb White Leghorn					Rhode Island Red				
		Young	Half-grown	Mature			Young	Half grown	Mature		
		3-4 wk	10-12 wk	36-52 wk			3 wk	11-12 wk	36-52 wk		
		♂0.25 kg	♂0.91 kg	♀1.82 kg			♂0.25 kg	♂1.25 kg	♀2.5 kg		
		Growth	Growth	Maintenance	Laying	Breeding	Growth	Growth	Maintenance	Laying	Br[…]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	
1	Water, ml	575[1]	200[2]	110[3]	110[3]	110[3]	575[1]	140[2]	80[3]	80[3]	
2	Calories[4] metabolizable	300		150	150	150					
3	Total feed, g	132	78	39	60	60	124	80	35	30	
4	Residue, g	5			3	3	6		3	3	
5	Protein[5], g	26.0	12.5	6.0	9.0	9.0	24.0	12.7	?	7.4	
6	Carbohydrate, g	50			25	25	70	32	18	25	
7	Fat[6], g	3.0	1.6	1.0	1.2	1.2	3.2	1.5	1.0	1.0	
8	"Essential" fatty acids										
9	Vitamin A, equiv. as β-carotene[7], mg	0.21	0.12	?	0.16	0.16	0.20	0.13	?	0.13	
10	Ascorbic acid[8]										
11	Biotin, µg	12	7		8	7	11	7		7	
12	Choline, mg	175	111		56	56	165	105		50	
13	Cobalamin[9], µg	1.2				0.2	1.2				
14	Vitamin D, equiv. as cryst. D_3[10], µg	0.66	0.38	?	0.75	0.75	0.62	0.40	?	0.62	
15	Vitamin E[11], mg	2.6	1.4				2.8	1.5			
16	Folic acid group[12], mg	0.07	0.04		0.015	0.021	0.07	0.04		0.01	
17	Inositol[8]										
18	Vitamin K[13], µg	52	28				55	26			
19	Niacin[14], mg	3.5	1.1			0.45	3.3	1.0			
20	Pantothenic acid, mg	1.25	0.75	0.22	0.28	0.55	1.15	0.74		0.25	
21	Para-aminobenzoic acid[8]										
22	Pyridoxine group[15], mg	0.58	0.24	?	0.17	0.17	0.56	?		0.14	
23	Riboflavin, mg	0.58	0.14	?	0.13	0.25	0.56	0.14	?	0.11	
24	Thiamine, mg	0.24	0.11				0.22	?			
25	Calcium, mg	1320	781	395	1350	1350	1240	800	?	1130	11
26	Chlorine, mg	400	280	118	160	160	425	210	109	140	1
27	Cobalt[16]										
28	Copper, mg	0.26	0.22				0.28	0.20			
29	Fluorine[8]										
30	Iodine, mg	0.14	0.05		0.05	0.07	0.14	0.05		0.02	
31	Iron[17], mg	2.5	2.2				3.5	1.7			
32	Magnesium, mg	64	29				60	?			
33	Manganese, mg	7.3				2.0	6.8	?			
34	Phosphorus, mg	735	475	?	565	565	744	480	?	300	3
35	Potassium, mg	265	124				247	130			
36	Silicon										
37	Sodium, mg	204	144	78	102	102	220	130		90	
38	Sulfur[18]										
39	Zinc										

/1/ Based on 3.3 gal per 100 chicks daily. /2/ Based on 4.7 gal per 100 chicks daily. /3/ Based on 4.8 gal per 100 hens daily[…] Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the […] from the food absorbed. /5/ Crude. /6/ Based on 2.5% fat in ration of mash and scratch. /7/ 0.0006 mg β-carotene = one I. U[…] Presumably utilized but not required in diet. /9/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation p[…] (known variously as B_{12b} or B_{12a}) which has approximately the same biological activity. /10/ 0.025 µg crystalline D_3 (7-dehydro[…]terol) = one International Chick Unit. The chicken utilizes D_2 poorly. /11/ A generic term for alpha-, beta-, delta- and gam[…] tocopherols. /12/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin B_c, vitam[…] factor U, L. casei factor, [illegible] factor. /13/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-p[…] 1,4-naphthoquinone), synthetic vitamin K (menadione, 2-methyl-1,4-naphthoquinone) and vitamin K_2 (2-methyl-3-difarnesyl-1,4-nap[…] quinone). /14/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); al[…] pellagra preventive (P-P) factor, anti-blacktongue factor. /15/ Includes pyridoxine, pyridoxal and pyridoxamine. /16/ Re[…] only in form of cobalamin. /17/ 25 ppm of food considered optimum. /18/ Required only in form of methionine or cystine.

46 DAILY NUTRIENT ALLOWANCES TURKEY

Values are approximations to adequate requirements for normal growth health and productivity Presentation of values in terms of "per kg body weight per day" i for purposes of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight within the species For diets that supply these nutrient allowances see table 40, Diets: Laboratory and Domestic Animal

	Specifications / Nutrients per kg body weight per day	Broad breasted Bronze Turkeys: Young	Half-grown	Mature
		8-9 wk	16 wk	40-52 wk
		♂[illegible] kg	♀4 kg ♂6 kg	♀8 kg
		Growth		Breeding
	(A)	(B)	(C)	(D)
1	Water			
2	Calories metabolizable			
3	Total food g	75	52	38
4	Residue			
5	Protein[1] g	21	10.5	4.8
6	Carbohydrate			
7	Fat g	2.1	2.0	1.5
8	"Essential" fatty acids			
9	Vitamin A, calc. as β-carotene[2] mg	0.24	0.17	0.10
10	Ascorbic acid			
11	Biotin			
12	Choline mg	127		
13	Cobalamin[3]			
14	Vitamin D calc. as cryst. D_3[4] µg	1.7	1.2	0.7
15	Vitamin E[5]			
16	Folic acid group[6] mg	0.07		0.2
17	Inositol			
18	Vitamin K[7]	0.10		
19	Niacin[8] mg	3.7		

	Specifications / Nutrients per kg body weight per day	Broad breasted Bronze Turkeys: Young	Half-grown	Mature
		8-9 wk	16 wk	40-52 wk
		♂[illegible] kg	♀4 kg ♂6 kg	♀8 kg
		Growth		Breeding
	(A)	(B)	(C)	(D)
20	Pantothenic acid mg	0.85	0.62	0.42
21	Para-aminobenzoic acid			
22	Pyridoxine group[9] mg	0.26		
23	Riboflavine mg	0.28	0.09	0.11
24	Thiamine			
25	Calcium, g	1.5	1.04	0.72
26	Chlorine[10,11] g	0.22	0.15	0.10
27	Cobalt			
28	Copper			
29	Fluorine			
30	Iodine mg	0.06	0.06	0.05
31	Iron			
32	Magnesium			
33	Manganese mg	4.1		1.1
34	Phosphorus[12] g	0.75	0.52	0.24
35	Potassium g	0.10	0.10	0.05
36	Silicon			
37	Sodium[13] g	0.17	0.10	0.06
38	Sulfur			
39	Zinc			

/1/ Crude /2/ 0.0006 mg β-carotene = one I U /3/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /4/ 0.025 µg crystalline D_3 (7-dehydrocholesterol) = one I U /5/ A generic term for alpha- beta- delta- and gamma-tocopherols /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M, vitamin B_c, factor U L. casei factor Norite eluate factor /7/ The anti-hemorrhagic factor A generic term for vitamin K_1 (2-methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione = 2-methyl 1,4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl 1,4-naphthoquinone) /8/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide); also for pellagra preventive (P P) factor anti-blacktongue factor /9/ Includes pyridoxine pyridoxal and pyridoxamine /10/ Represents chlorine added as NaCl to the diet in addition to any Cl present in association with other nutrients /11/ Chlorine rather than sodium may be the limiting factor in practical poultry feeds /12/ At least two-fifths of this requirement should be supplied as inorganic PO_4 /13/ Represents sodium in added NaCl (cf fn 10)

45 DAILY NUTRIENT ALLOWANCES CHICKEN

Values are approximations to adequate requirements for normal growth, health and productivity. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply the allowances in these columns, see table 50, Diets: Laboratory and Domestic Animals.

Specifications / Nutrients per kg body weight per day	Single Comb White Leghorn					Rhode Island Red				
	Young	Half-grown	Mature			Young	Half-grown	Mature		
	3-4 wk	10-12 wk	56-58 wk			3 wk	11-12 wk	56-58 wk		
	♂ 0.25 kg	♂♀ 0.91 kg	♀ 1.62 kg			♂♀ 0.25 kg	♂♀ 1.25 kg	♀ 2.5 kg		
	Growth	Growth	Maintenance	Laying	Breeding	Growth	Growth	Maintenance	Laying	Breeding
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1 Water ml	575[1]	200[2]	110[3]	110[3]	110[3]	575[1]	140[2]	80[3]	80[3]	80[3]
2 Calories[4] metabolizable	500		150	150	150					
3 Total feed, g	132	78	39	60	60	124	80	35	50	50
4 Residue g	5			5	5	6		5	5	
5 Protein[5] g	26.0	12.5	6.0	9.0	9.0	24.0	12.7	?	7.4	7.4
6 Carbohydrate g	50			25	25	70	32	18	25	
7 Fat[6] g	3.0	1.6	1.0	1.2	1.2	3.2	1.5	1.0	1.0	1.0
8 "Essential" fatty acids										
9 Vitamin A, calc as β-carotene[7], mg	0.21	0.12	?	0.16	0.16	0.20	0.13	?	0.13	0.13
10 Ascorbic acid[8]										
11 Biotin, µg	12	7		8	7	11	7		7	6
12 Choline mg	175	111		56	56	165	109		50	50
13 Cobalamin[9] µg	1.2				0.2	1.2				0.2
14 Vitamin D, calc as cryst D_3[10] µg	0.66	0.38	?	0.75	0.75	0.62	0.40	?	0.62	0.62
15 Vitamin E[11] mg	2.6	1.4				2.8	1.3			
16 Folic acid group[12] mg	0.07	0.04		0.015	0.021	0.07	0.04		0.01	0.02
17 Inositol[8]										
18 Vitamin K[13] µg	52	28				55	26			
19 Niacin[14] mg	3.5	1.1			0.45	3.3	1.0			
20 Pantothenic acid, mg	1.25	0.75	0.22	0.28	0.55	1.15	0.74		0.25	0.46
21 Para-aminobenzoic acid[8]										
22 Pyridoxine group[15] mg	0.58	0.24	?	0.17	0.17	0.56	?		0.14	0.14
23 Riboflavine mg	0.58	0.14	?	0.13	0.25	0.56	0.14	?	0.11	0.19
24 Thiamine mg	0.24	0.11				0.22	?			
25 Calcium, mg	1520	781	595	1550	1550	1240	800	?	1150	1150
26 Chlorine mg	400	280	118	160	160	425	210	109	140	140
27 Cobalt[16]										
28 Copper mg	0.26	0.22				0.28	0.20			
29 Fluorine[8]										
30 Iodine mg	0.14	0.05		0.05	0.07	0.14	0.05		0.02	0.05
31 Iron[17] mg	2.5	2.2				3.5	1.7			
32 Magnesium, mg	64	29				60	?			
33 Manganese mg	7.5				2.0	6.8	?			1.7
34 Phosphorus mg	795	475	?	365	363	744	480	?	300	300
35 Potassium, mg	265	124				247	230			
36 Silicon										
37 Sodium, mg	254	144	78	102	102	250	130		90	90
38 Sulfur[18]										
39 Zinc										

/1/ Based on 3.3 gal per 100 chicks daily /2/ Based on 4.7 gal per 100 chicks daily /3/ Based on 4.8 gal per 100 hens daily /4/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. /5/ Crude /6/ Based on 2.5% fat in ration of mash and scratch. /7/ 0.0006 mg β-carotene = one I. U. /8/ Presumably utilized but not required in diet /9/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /10/ 0.025 µg crystalline D_3 (7-dehydrocholesterol) = one International Chick Unit. The chicken utilizes D_2 poorly /11/ A generic term for alpha-, beta-, delta- and gamma-tocopherols /12/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor /13/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone) and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone) /14/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor /15/ Includes pyridoxine, pyridoxal and pyridoxamine. /16/ Required only in form of cobalamin. /17/ 25 ppm of feed considered optimum. /18/ Required only in form of methionine or cystine

46 DAILY NUTRIENT ALLOWANCES TURKEY

Values are approximations to adequate requirement for normal growth health and productivity Presentation of values in terms of "per kg body weight per day" is for purpose of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight within the species For diets that supply these nutrient allowances see table 50 Diets: Laboratory and Domestic Animal

Specifications / Nutrients per kg body weight per day	Broad breasted Bronze Turkeys: Young	Half grown	Mature
	6-9 wk	16 wk	40-52 wk
	0.72 kg	5.4 kg/6.6 kg	9.8 kg
	Growth		Breeding
(A)	(B)	(C)	(D)
1 Water			
2 Calories metabolizable			
3 Total feed g	75	52	32
4 Residue			
5 Protein[1] g	21	10 5	4 8
6 Carbohydrate			
7 Fat g	2 1	2 0	1.3
8 "Essential" fatty acids			
9 Vitamin A calc. as β-carotene[2] mg	0.24	0 17	0 10
10 Ascorbic acid			
11 Biotin			
12 Choline mg	125		
13 Cobalamin[3]			
14 Vitamin D, calc. as cryst. D_3[4] µg	1 7	1.2	0 7
15 Vitamin E[5]			
16 Folic acid group[6] mg	0 07		0.2
17 Inositol			
18 Vitamin K[7]	0 10		
19 Niacin[8] mg	3 7		
20 Pantothenic acid mg	0.85	0.62	0.42
21 Para-aminobenzoic acid			
22 Pyridoxine group[9] mg	0.26		
23 Riboflavin mg	0.26	0 09	0 11
24 Thiamine			
25 Calcium, g	1.5	1.04	0 72
26 Chlorine[10 11] g	0.22	0 15	0 10
27 Cobalt			
28 Copper			
29 Fluorine			
30 Iodine mg	0 06	0 06	0 05
31 Iron			
32 Magnesium			
33 Manganese mg	4 1		1.1
34 Phosphorus[12] g	0.75	0.52	0.24
35 Potassium g	0 10	0.10	0.05
36 Silicon			
37 Sodium[13] g	0 17	0 10	0 06
38 Sulfur			
39 Zinc			

/1/ Crude /2/ 0 0006 mg β-carotene one I U /3/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /4/ 0 025 µg crystalline D_3 (7-dehydrocholesterol) = one I U /5/ A generic term for alpha beta- delta- and gamma-tocopherols /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M, vitamin B_c, factor U L. casei factor Norite eluate factor /7/ The anti hemorrhagic factor A generic term for vitamin K_1 (2 methyl 3-phytyl 1 4-naphthoquinone) synthetic vitamin K (menadione = 2-methyl 1 4-naphthoquinone) and vitamin K_2 (2-methyl 3-difarnesyl-1,4-naphthoquinone) /8/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti-blacktongue factor /9/ Includes pyridoxine pyridoxal and pyridoxamine /10/ Represents chlorine added as NaCl to the diet in addition to any Cl present in association with other nutrients /11/ Chlorine rather than sodium may be the limiting factor in practical poultry feeds /12/ At least two-fifths of this requirement should be supplied as inorganic PO_4 /13/ Represents sodium in added NaCl (cf Fn 10)

47 DAILY NUTRIENT ALLOWANCES FISH

Values are approximations to adequate allowances intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of per kg body weight per day" is for purposes of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight within the species

Required (R); No demonstrated requirement (Ø)

Specifications / Nutrients per kg body weight per day	Trout[1]				Salmon[1,2]			
	Brook	Brown	Cutthroat	Rainbow	Chinook	Chum	Silver	Sockeye
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
1 Calories, metabolizable								
2 Total feed, g								
3 Residue								
4 Protein								
5 Carbohydrate[3] g	1.0-5 0	1 0-5 0	1.0-5 0	1 0-5 0	1 0-4 0		1 0-5 0	1 0-5.0
6 Fat								
7 "Essential fatty acids								
8 Vitamin A	R?	R?	R?	R?	R?	R?	R?	R?
9 Ascorbic acid, mg	R?	R?	R?	20-40[4]	R?	R?	R?	R?
10 Biotin, µg	10-26	43-76	R?	15-26	R	R?	R?	R
11 Choline, mg	R?	R?	R?	4-8[4]	R?	R?	R?	R?
12 Cobalamin[5]	R?	R?	R?	R?	R	R?	R?	R
13 Vitamin D	R?	R?		R?				
14 Vitamin E	R?	R?	R?	Ø	R?	R?	R?	R?
15 Folic acid group[6] mg	0 1-0.2	0.1-0.2	R?	0.1-0.2	R?			
16 Inositol, mg	R	R	R?	20-40[4]	R?			R?
17 Vitamin K								
18 Niacin[7] mg	3-4	3-4		3-4[8]	R?			R?
19 Pantothenic acid, mg	1 1 3	1 1 3	R?	1 1 3	R	R?	R	R
20 Para-aminobenzoic, mg				8-16[4]				
21 Pyridoxine group[9] mg	0.2-0 3	0.2-0 3	R?	0 2-0 3	R?			R?
22 Riboflavine mg	0 4-0 7	0 4-0 7	R?	0 4-0 7	R?		R?	R?
23 Thiamine, mg	0 1-0.2	0.1-0.2	R	0 1-0.2	R	R?	R	R
24 Calcium								
25 Chlorine								
26 Cobalt								
27 Copper								
28 Fluorine								
29 Iodine	R	R	R?	R				
30 Iron								
31 Magnesium								
32 Manganese								
33 Phosphorus								
34 Potassium								
35 Silicon								
36 Sodium								
37 Sulfur								
38 Zinc								

/1/ Fresh water /2/ Salt water /3/ Recommended maximum levels to feed. /4/ Calc from food intake per day and assumed average body weight of 4-months-old fingerling trout (McLaren et al 47) /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c factor U L casei factor Norite eluate factor /7/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P P) factor anti blacktongue factor /8/ Only 0 08-0 4 mg according to McLaren et al 47 /9/ Includes pyridoxine pyridoxal and pyridoxamine

48 DIETS, LOW COST: MAN, U S A

The table presents the percentage composition of a satisfactory "low cost" diet for persons of different ages, male and female, living within the area of the U.S.A. All values are based on total weight of food as purchased (fresh and canned fruits and vegetables, shell eggs, fluid milk, etc.). Values are not comparable to figures on dry weight basis such as often used to define diets of other species. Ready availability throughout the area, costs, and the food habits of the population have been factors in determining the make-up of the food groups (columns E-O) and percentages allotted to each. The quantities in column C provide the nutrients prescribed in tables 31-36, Daily Nutrient Allowances: Man.

	Age and Sex	Assumed Body Weight[1]	Total Food		Percentage Composition of Diet: Citrus Fruits Tomatoes	Leafy Green and Yellow Vegetables	Potatoes Sweet-Potatoes	Other Vegetables and Fruits	Eggs[2]	Milk[3]	Meat Poultry Fish	Dry Beans and Peas Nuts	Flour[4] Cereals	Fats[5] and Oil	Sugar Syrups Preserves
		kg	g/kg/day	kg/person/wk	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
	Children through 12 yr														
1	9-12 mo	10.0	120[6]	8.6	8.3	7.9	2.6	5.3	2.6	66	1.3	0.3	5.2	0.3	0.3
2	1-3 yr	13.4	95	8.9	8.9	8.9	5.1	5.1	2.5	69	2.5	0.3	7.4	0.6	0.6
3	4-6 yr	19.6	78	9.9	8.0	8.0	6.9	5.7	2.3	52	4.6	0.6	8.0	1.7	1.7
4	7-9 yr	27.9	58	11.3	8.0	8.0	10.0	6.0	2.0	46	6.0	1.1	9.0	2.0	2.3
5	10-12 yr	38.0	50	13.2	7.7	7.7	10.3	6.0	1.7	39	6.0	0.8	11.2	2.6	2.6
	Girls														
6	13-15 yr	50.7	40	14.0	7.3	7.3	10.3	5.7	1.6	44	6.4	0.8	11.3	2.4	2.4
7	16-20 yr	57.4	30	12.2	8.4	8.4	11.2	6.5	1.8	38	7.4	0.9	12.0	2.9	2.3
	Boys														
8	13-15 yr	49.3	45	15.6	7.5	7.3	11.7	6.6	1.4	40	5.8	1.4	13.1	2.9	2.5
9	16-20 yr	66.1	37	17.0	6.7	7.3	13.3	6.7	1.3	36	5.5	1.3	15.3	3.7	2.7
	Women														
10	Sedentary	56.0	28	11.1	8.1	9.2	9.2	7.2	2.0	42	8.1	1.0	8.1	2.6	2.6
11	Moderately active	56.0	30	11.7	7.7	8.7	11.6	6.6	1.9	40	7.7	1.0	8.7	2.9	2.9
12	Very active	56.0	33	13.8	8.2	8.2	13.2	6.6	1.6	34	6.6	1.2	14.0	3.3	3.3
13	Pregnant	56.0	38	14.9	7.6	9.1	7.6	6.1	2.1	49	6.9	0.8	7.6	1.9	1.5
14	Nursing	56.0	51	19.9	8.5	8.0	9.1	5.1	1.6	52	5.7	0.6	6.8	1.4	1.1
15	60 years or over[7]	56.0	30	11.3	9.0	10.0	10.0	7.0	1.6	41	8.0	0.5	9.0	2.0	2.0
	Men														
16	Sedentary	70.0	24	11.6	7.8	8.8	6.9	6.9	1.9	40	7.8	1.0	12.7	2.9	2.9
17	Physically active	70.0	28	13.8	8.2	8.2	13.2	6.6	1.6	34	6.6	1.2	14.0	3.3	3.3
18	With heavy work	70.0	35	17.0	6.7	6.7	16.0	6.7	1.3	27	5.3	1.7	20.7	3.0	2.7
19	60 years or over[7]	65.0	27	12.3	8.3	9.3	12.0	6.5	1.5	38	7.4	0.5	12.0	2.3	2.3

/1/ These weights are average for North American whites. Values for children are for the mid-age in the ranges given. Where sex is not specified and a weight difference exists, the weight for males has been presented. /2/ One medium egg weighs approximately [illegible] grams. /3/ Milk requirements for children can be replaced by equivalent quantities of evaporated milk (7½% water) or dry milk (3-4% water) or its equivalent (on protein and calcium basis, not moisture) in evaporated milk, dry milk, cheese or ice cream. /4/ 1.5 grams of bread may be considered the equivalent of 1 gram of flour. The foods in this group should be supplied frequently in the form of wholegrain, enriched, or restored products. /5/ For small children and pregnant and nursing women, cod-liver oil or some other source of vitamin D is also needed. For elderly persons and for those who have no opportunity for exposure to clear sunshine, small amounts of vitamin D is also desirable. /6/ Value high because the total intake of infants is chiefly milk and has, therefore, an unusually high water content (cf Fn 3). /7/ Sedentary

49 DIETS, MODERATE COST MAN U S A

The table presents the percentage composition of satisfactory moderate cost diet for persons of different ages male and female living within the area of the U S A Ready availability throughout this area, costs and the food habits of the population have been factors in determining the make-up of the food groups (columns E-O) and the percentages allotted to each The quantities in Column C provide the nutrients prescribed in tables 31, 32, Daily Nutrient Allowances: Man

	Age and Sex	Assumed Body Weight[1]	Total Food		Percentage Composition of Diet										
					Citrus Fruits Tomatoes	Leafy Green and Yellow Vegetables	Potatoes Sweet-Potatoes	Other Vegetables and Fruits	Eggs[2]	Milk[3]	Meat Poultry Fish	Dry Beans and Peas Nuts	Flour[4] Cereals	Fats[5] and Oils	Sugar Syrups Preserves
		kg	g/kg/day	lb/person/wk	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
	Children through 12 yr														
1	9-12 mo	10.0	120[6]	8.6	9.3	7.9	2.6	5.3	2.6	66	1.3	0.3	3.3	0.3	0.3
2	1-3 yr	13.4	105	9.8	9.2	9.2	2.3	8.1	2.3	58	3.4	0.3	3.7	0.3	0.3
3	4-6 yr	19.6	88	11.2	9.1	9.1	4.1	9.1	2.8	51	3.0	0.3	6.1	1.3	2.0
4	7-9 yr	27.9	67	13.0	8.7	8.7	6.1	8.7	2.4	48	6.1	0.4	6.9	1.7	2.6
5	10-12 yr	38.0	56	14.8	8.4	9.2	6.9	7.7	2.1	43	6.9	0.4	8.4	2.3	2.7
	Girls														
6	13-15 yr	50.7	45	15.9	7.8	10.0	7.1	10.0	2.0	42	7.8	0.3	7.8	2.3	2.3
7	16-20 yr	57.4	37	14.7	8.4	10.8	7.7	10.8	2.1	39	8.4	0.4	7.7	2.3	2.7
	Boys														
8	13-15 yr	49.3	51	17.7	7.7	9.0	10.3	9.0	1.8	38	7.7	0.6	10.3	2.9	2.9
9	16-20 yr	66.1	42	19.3	8.3	9.4	10.6	8.3	1.6	33	7.7	0.9	12.4	3.2	2.9
	Women														
10	Sedentary	56.0	32	12.3	9.1	11.8	6.4	11.8	2.3	38	9.1	0.2	6.4	2.3	2.7
11	Moderately active	56.0	35	13.7	8.3	11.6	8.3	11.6	2.3	34	9.1	0.4	8.3	2.9	2.9
12	Very active	56.0	40	15.6	8.7	10.9	9.3	11.7	2.0	30	8.7	0.7	10.9	3.3	3.3
13	Pregnant	56.0	42	16.3	9.8	11.1	6.3	8.3	1.9	44	8.3	0.3	6.3	1.7	1.7
14	Nursing	56.0	52	20.4	10.0	8.9	6.7	7.8	1.3	49	6.7	0.3	5.6	1.7	1.7
15	60 yr or over[7]	56.0	33	13.0	9.3	12.2	6.9	10.4	2.1	40	8.7	0.2	6.1	1.7	2.2
	Men														
16	Sedentary	70.0	28	13.7	8.3	11.6	8.3	11.6	2.3	34	9.1	0.4	8.3	2.9	2.9
17	Physically active	70.0	32	15.6	8.7	10.9	9.3	11.7	2.0	30	8.7	0.7	10.9	3.3	3.3
18	With heavy work	70.0	39	19.0	8.4	9.3	11.9	10.1	1.7	25	8.4	0.9	16.7	4.8	3.0
19	60 yr or over[7]	65.0	32	14.3	8.6	10.9	8.6	9.4	1.9	39	8.6	0.4	7.8	2.3	2.3

/1/ These weights are average for North American whites Values for children are for the mid-age in the ranges given Where sex is not specified and weight difference exists the weight for males has been presented. /2/ One medium egg weighs approximately 54 grams /3/ It should be noted that milk contains about 87% water Milk requirements can be replaced by equivalent quantities of cheese (Cheddar cheese 40% water; cottage cheese 75% water) or evaporated milk 74% water; or dry milk 3-4% water /4/ 1 3 grams of bread may be considered the equivalent f 1 gram of flour The foods in this group should be supplied frequently in the form of wholegrain, enriched, or restored products /5/ For small children and pregnant and nursing women, cod-liver il or some other source of vitamin D i also needed For elderly persons and for those who have no opportunity for exposure to clear sunshine small amount of vitamin D is also desirable /6/ Value high because the total food intake of infants is chiefly milk and therefore contains high proportion of water (cf F 3) /7/ Sedentary

50 DIETS LABORATORY AND DOMESTIC ANIMALS

Diets have been selected from a large number of pos ible di ts. They are not necessarily optimal nor do they suit all important conditions and feeding purposes. Consult texts on feeding (see biblio.) for more detailed information. Unless otherwise indicated values in col E are grams/100 g (or lb/100 lb) of ration

Species	Age	Body Weight	Daily Food Intake[1]	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Cattle Beef				
Normal growth		227	28	Alfalfa hay 71; barley 14 5; corn yellow 14 5
Fattening calf		272	I 38 II 38 III-27	Diet I: Alfalfa hay 13 8; corn silage 43 corn 37; cottonseed meal 4 3. Diet II Prairie hay 15 1; corn silage 44; corn 36; cottonseed meal 7 4; $CaCO_3$ 0 2 Diet III: Vetch and oat hay 3?; beet pulp molasses 74 5; barley 36; cottonseed meal 5 1
Yearling steer		363	23	Oat hay moderately green 25; alfalfa hay 10; barley 30; beet pulp molasses dried 20; molasses cane 10; cottonseed meal (41% protein) 5.
Wintering pregnant cow		408	I-23 II-22 III-44	Diet I: Alfalfa hay 19 8; oat hay 80 Diet II: Corn fodder 49; barley straw 25; alfalfa hay 25 Diet III: Corn silage 69; oat straw 27; cottonseed meal (41% protein) 4 1
Cattl Dairy				
Calf		45	120	Whole milk 100.
Heifer		87?	I 29 II 31 III-25 IV-46	Diet I: Mixed legume-grass hay 66; oats (corn or barley) 34 Diet II: Alfalfa hay 100 Diet III: Timothy hay 66; barley 33; limestone 0 4 Diet IV: Alfalfa hay 40; corn silage 60.
Mature lactating cow		635	I 30 II 33 III 33	Diet I: Alfalfa 75; barley 25 Diet II: Timothy hay 19.1; corn silage 58; corn and cob meal 16 3; soybean meal 6.8; limestone 0.3 Diet III Alfalfa hay 29; corn silage 70 7; steamed bone meal 0 3
Chicken Germ-free				
♂Barten	1	0 11	140	Casein 25; gelatin, 10; L-cystine 0 2; corn oil 6; corn starch 45; lactose 4; whole liver powder (pork) 2; yeast extract 2; vitamin A esters 400 I U.; ascorbic acid 0.2; vitamin D_3 50 A. O A. C units; tocopherol 0 025; 2-methyl 1 4-naphthoquinone 0.005; thiamine Cl.HCl 0 006; riboflavine 0 005; calcium pantothenate 0 02; nicotinamide 0 05; choline Cl 0.2; pyridoxine Cl 0 002 i inositol 0 1; biotin, 0 00001; folic acid 0 001; $CaCO_3$ 1 5; $CaHPO_4$ 0.28; K_2HPO_4 1; NaCl 0.85; KI 3 16; $MgSO_4 \cdot 7H_2O$ 0.07; $FeC_6H_5O_7$ 0.38; $CuSO_4 \cdot 5H_2O$ 0 02; $CaCl_2 \cdot 6H_2O$ 0 025; $ZnSO_4 \cdot 7H_2O$ 0.005; $Na_2B_4O_7 \cdot 10H_2O$ 0 005; $AlK(SO_4)_2 \cdot 12H_2O$, 0 004
♂White Leghorn	1	0.12	80	Same diet as Barten.
Chicken Rhode Island Red				
♂Young	0 7	0 25	140	Corn ground yellow 49; standard wheat middlings 10; alfalfa meal (75,000 or more I U of vitamin A per lb) 5; soybean oil meal 20; fish meal 4; meat meal, 4; steamed bone meal 1; ground limestone 1; dried whey 5; salt 0 5; vitamin A and D feeding oil 0 1 (oil contains 300 International Chick Units vitamin D 1500 I U vitamin A per gram); plus anhydrous $MnSO_4$ 0.0125 g per 100 g feed.

/1/ The numerals I II III IV occurring occasionally in column D refer to alternative dietary mixtures whose compositions are given in column E.

Diets have been selected from a large number of possible diets They are not necessarily optimal nor do they suit all important conditions and feeding purposes Consult texts on feeding (see biblio) for more detailed information. Unless otherwise indicated, values in col. E are grams/100 g (or lb/100 lb) of ration

Species	Age	Body Weight	Daily Food Intake[1]	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Chicken Rhode Island Red (concluded)				
♂ Half-grown	2.1	1.25	67	Corn ground yellow 47; standard wheat middlings 15; wheat bran, 10; alfalfa meal 5 (meal contains 75 000 or more I. U of vitamin A per lb); soybean oil meal 17; dried whey 2; steamed bone meal 2.5; ground limestone 1; salt 0 5; vitamin A and D feeding oil[2] 0.1; plus anhydrous $MnSO_4$ 0 0125 g per 100 g feed.
♀ Mature breeding	7.2 10 4	2.5	45	Corn, ground yellow 49; standard wheat middlings 15; wheat bran, 10; alfalfa meal 5 (meal contains 75 000 or more I. U of vitamin A per lb); soybean oil meal 4; fish meal 4; meat meal 4; dried whey 4; steamed bone meal 1; ground limestone 3 5; salt 0 5; vitamin A and D feeding oil[2] 0 5; plus anhydrous $MnSO_4$ 0 0125 g per 100 g feed.
Dog				
Young		4 5	55	Meat meat by-products including bone or fish 20; soybean meal, wheat germ corn germ, or nut meal 20; corn, wheat or barley 50; carrots beet by products or tomato by-products 2 5; iodized salt 0 ?–0 5; milk liver meals or fermentation solubles q ; fish liver oils and irradiated yeast q
Adult		13 6	I 22 II-22?	Diet I: Same as foregoing diet for young dog Diet II (a basic purified diet): Casein vitamin-free 10; dextrose 15; dextrin, 8; lard 6; salt mixture Wesson 32 0 8 (composed of: NaCl, 10 5; KCl 12; KH_2PO_4 31; $Ca_3(PO_4)_2$ 14 9; $CaCO_3$, 21; $MgSO_4$ 9; $FePO_4$ $4H_2O$ 1.47; $MnSO_4$ 0 02; $K_2Al_2(SO_4)_4$ $24H_2O$ 0.009; $CuSO_4$ $5H_2O$ 0 039; NaF 0 057 KI 0 005); agar, 1.2; distilled water 58 To each 1000 g of dry ingredients add thiamine 2.0 mg; riboflavine 1.6 mg; nicotinic acid 16 0 mg; calcium pantothenate 13 0 mg; pyridoxine 1.0 mg; choline 1 g; 2-methyl-naphthoquinone (vitamin K) 0 6 µg; alpha tocopherol (vitamin E) 55 mg; biotin, 0.6 mg; folic acid 0 6 mg; vitamin A 30 g; vitamin D 5 g; vitamin B_{12} 1 mg
Fish				
Fish trout brook brown and rainbow	0.0–3	0 0001 0 002	80–100 at 10° C[3]	Diet I[4]: Beef liver 49; pork spleen, 49; salt 2. Diet II[4]: Beef liver 100 Diet III[4]: Beef liver, 60; horse meat, 40
	3–9	0.002–0 05	20–60 at 10° C[3]	Diet I[4]: Pork or beef spleen 35; beef liver 15; salt, 2; fish meal 12; wheat middlings 12; dried skim milk or distillers solubles 12; cottonseed meal 12. Diet II[4] Beef liver 33; beef spleen, 33; horse meat 34. Diet III[4]: Cooked carp or other rough fish 45; oatmeal, 5; beef liver, 15; beef or pork spleen, 35.
	4	0 004	60 at 10° C[3]	Diet I: Casein 35; gelatin 15; crisco or lard 9; potato starch (cooked) 8; cella flour 9; minerals 4 (composed of U.S.P XII salt mixture No. 2: sodium chloride 1.73 g; magnesium sulfate 5.45 g; sodium biphosphate 3 47 g; potassium phosphate 9 54 g; calcium biphosphate 5.4 g; ferric citrate 1.18 g; calcium lactate 13 g to which the following trace ele-

/1/ The numerals I II III IV occurring occasionally in column D refer to alternative dietary mixtures whose compositions are given in column E. /2/ See item 45 column E for composition. /3/ Food allowance for trout i is proportion to body size and water temperature (the larger the fish the smaller allowance in proportion to body weight and the higher the temperature within limits the greater the allowance) /4/ Hatchery rearing diet

50 DIETS LABORATORY AND DOMESTIC ANIMALS (Continued)

Diets have been selected from a large number of possible diets They are not necessarily optimal, nor do they suit all important conditions and feeding purposes Consult texts on feeding (see biblio) for more detailed information Unless otherwise indicated, values in col E are grams/100 g (or lb/100 lb) of ration

Species	Age	Body Weight	Daily Food Intake/1/	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Fish (concluded)				
Fish trout brook brown and rainbow (concluded)	4	0 004	60 at 10° C/3/	...ments have been added per 100 g: aluminum chloride 18 mg; zinc sulfate, 357 mg; copper gluconate 311 mg; manganous sulfate 80 mg; potassium iodide 17 mg; cobalt chloride 105 mg); vitamin supplement (composed of the following per 100 g: thiamine 6 mg; riboflavine 20 mg; Pyridoxine 4 mg; choline 800 mg; para-aminobenzoic acid 40 mg; niacin 80 mg; calcium pantothenate 28 mg; inositol 400 mg; biotin 0.6 mg; folic acid, 1.5 mg; B_{12} 9 µg; alpha tocopherol 40 mg; vitamin K 4 mg; vitamin C 200 mg; vitamin A and D cod liver oil to replace same amount of fat in original formula 8ml); water added at the rate of 300 g per 100 g dry ingredients.
Horse				
Maintenance		544	16	Oat or barley 100
Medium work		544	19	Timothy hay 65; oats 15; corn 21 8
Pregnant mare		544	18	Alfalfa hay 18 9; prairie hay 43; oats 38
Lactating mare		544	21	Timothy hay 52; alfalfa hay 26; oats 40
Growing colt		272	25	Timothy hay 42; alfalfa hay 14 5; oats 22; corn, 14 5; wheat bran 7 1.
Monkey Rhesus Juvenile				
Mature		1.5-3	40	Sucrose 71; de-vitaminized casein 18; corn oil 4; salt mixture, 5 (composed of $CaCO_3$ 300 g; K_2HPO_4 470 g; $CaHPO_4$ 680 g; $MgSO_4$ 100 g; NaCl 670 g; KCl 115 g; $FeC_6H_5O_7$ 77 g; KI 1.6 g; $MnSO_4 \cdot H_2O$ 9 g; $ZnCl_2$ 4 g; $CuSO_4$ 2 4 g; $CoCl_2$ 0.2 g); whole liver substance 2; 1.2 liver concentrate powder 2. To each 18 g of casein add: thiamine hydrochloride 330 µg; pyridoxine hydrochloride 330 µg; nicotinamide 2.5 mg; choline chloride 100 mg; inositol 100 mg; para-aminobenzoic acid 30 mg; calcium pantothenat 2 mg; riboflavine 330 µg; folacin, 200 µg; biotin 20 µg; ascorbi acid 10 mg. To each 4 g of corn oil add: 90% β-carotene 90 µg; calciferol 0 8 µg α-tocopherol 5 mg; menadione 100 µg.
Rabbit New Zealand White				
Mature		5	68	Casein 20; dextrin 33; cellulose 15; soybean meal 10; salt mixture 4 (composed of 2.3% $MnSO_4 \cdot 4H_2O$ and 97 7% of the Hubbel Mendel and Wakeman mixture which is made up of the following minerals g per 4 g mixture Ca 0 87; P 0.20%; S 0 018; F 0 02; Mg 0 418; Na 0 11; K, 0.376; Fe 0 0018; Al 0 000096; I 0 0002; Mn, 0 005; Cu 0 0014; Cl 0 28)); yeast 15; A-D mixture/5/ 1.
Rat				
Cotton	6	0.18	72.2	Kale 4 8; apple 11 9; rat laboratory chow 48; rabbit pellets 29; carrots 4 8; peanut butter 2 0

/1/ The numerals I II, III, IV occurring occasionally in column D, refer to alternative dietary mixtures whose compositions are given in column E. /3/ Food allowance for trout is in proportion to body size and water temperature (the larger the fish, the smaller allowance is proportion to body weight and the higher the temperature within limits the greater the allowance) /5/ 1200 I U vitamin A and 170 I. U vitamin D

Diets have been selected from a large number of possible diets. They are not necessarily optimal, nor do they suit all important conditions and feeding purposes. Consult texts on feeding (see biblio.) for more detailed information. Unless otherwise indicated, values in col. E are grams/100 g (or lb/100 lb) of ration.

Species	Age	Body Weight	Daily Food Intake[1]	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Rat (concluded)				
White	1-6	0.18	50	Casein, 33; corn starch 37; lard 15; butter fat 9; No. 4 salt mixture 4 (composed of $CaCO_3$ 134.8 g; $MnCO_3$, 34.2 g; $MgCO_3$, 24.2 g; K_2CO_3, 141.3 g; H_3PO_4, 103.2 g; HCl 53 g; H_2SO_4 9.2 g; citric acid H_2O 111 g; F citrate H_2Ox 6.3 g; KI 0.02 g; $MnSO_4$ 0.079 g; NaF 0.248 g; $K_2Al_2(SO_4)_4$, 0.0245 g). To induce rapid growth of 4 or more grams per day 0.2-0.6 g of yeast and 20-30 g of fresh lettuce added daily
Sheep				
Bred ewes first 100 days of gestation		45	I 33 II 33 III-60	Diet I: Red clover hay 45; timothy hay, 55 Diet II: Prairie hay 57; alfalfa hay 43, Diet III Soybean hay 34; corn silage 66
Ewes in lactation		49 54 64	I-66 II-51 III 50	Diet I Corn silage 55; alfalfa hay 28; linseed meal 2.8; barley 13.8 Diet II: Corn silage 33; linseed meal 1.6; timothy hay 24.5; alfalfa hay 30; barley 11.5 Diet III Alfalfa hay 44; corn silage 35; barley 21.
Fattening lambs		32	I 120 II 37 III-48	Diet I: Barley (corn, oats or sorghum) 9.4; beet pulp wet 71; alfalfa hay 20.1. Diet II: Corn (barley or sorghum) 42; alfalfa, 58 Diet III: Corn 32; soybean oil meal 5.9; alfalfa hay 32; corn silage 30
Swine				
Swine		45	I 33 II 33 III 33 IV 33	Diet I[6]: Corn, 63; oats 15; soybean meal, 7.8; middlings 5; alfalfa meal, 5; limestone 0.7; salt, 0.5 Diet II[6] Barley 50; oats 40; linseed meal, 5; fish meal, 1; meat meal, 3.0; minerals 3[7]; A and D oil (99.3 I.U. vitamin A and 19.8 I.U. vitamin D/100 g of diet) Diet III[6]: Soybean meal, 8; alfalfa meal 4.5; barley 83; tankage 3; bonemeal, 0.5; limestone 0.5; salt (NaCl) 0.5 Diet IV[6]: Corn, 82; soybean meal, 6.5; meat and bone scrap 2.5; fish meal, 2.5; cottonseed meal, 2.5; alfalfa meal, 2.5; limestone 0.5; bonemeal, 0.5; salt (NaCl) 0.5
Turkey Broad-breasted Bronze				
♂Young	1.6-2.1	2	75	Corn ground yellow 29; standard wheat middlings 10; alfalfa meal 5 (meal contains 75,000 or more I.U. of vitamin A per pound); soybean oil meal 35; fish meal 6; meat meal 6; steamed bone meal 2; ground limestone 2; salt 0.5; dried whey 3; vitamin A and D feeding oil 0.5 (oil contains 300 International Chick Units vitamin D 1500 I.U. vitamin A per gram); plus anhydrous $MnSO_4$, 0.0125 g per 100 g feed.
♂Half-grown	3.2	6	52	Corn ground yellow 35; pulverized oat 20; alfalfa meal 4 (meal contains 75 000 I.U. vitamin A per pound); soybean oil meal 23; fish meal 4; meat meal 4; steamed bone meal 2.5; ground limestone 1.5; salt 0.5; dried whey 6; vitamin A and D feeding oil 0.5; (oil contains 300 International Chick Units vitamin D 1500 I.U. vitamin A per gram); plus anhydrous $MnSO_4$ 0.0125 g per 100 g of feed

/1/ The numerals I, II, III, IV occurring occasionally in column D, refer to alternative dietary mixtures whose compositions are given in column E. /6/ An antibiotic-vitamin B_{12} supplement is recommended for addition to all diets not otherwise provided with an antibiotic and vitamin B_{12} at a level suited to its type. /7/ Iodized salt (NaCl) 20%; steamed bonemeal, 37.7%; ground limestone 40%; ferrous sulfate 2%; manganese sulfate 0.2%; copper sulfate 0.1%.

50 DIETS LABORATORY AND DOMESTIC ANIMALS (Concluded)

Diets have been selected from a large number of possibl di ts They are not nece sarily optimal nor do they suit all important conditions and feeding purposes Consult texts on feeding (see biblio) for more detailed information Unless otherwise indicated values in col E are grams/100 g (or lb/100 lb) of ration.

	Species	Age	Body Weight	Daily Food Intake /1/	Diet
		mo	kg	g/kg body wt	g/100 g
	(A)	(B)	(C)	(D)	(E)
	Turkey Broad breasted Bronze (concluded)				
199	Half-grown	3 2	4	54	Corn ground yellow 35; pulverized oats 20 alfalfa meal 4 (meal contains 75 000 I. U vitamin A per pound); soybean oil meal 23; fish meal 4; meat meal 4; steamed bone meal 2 5; ground limestone 1 5; salt 0 5; dried hay 6; vitamin A and D feeding oil 0 5 (oil contains 300 International Chick Unit vitamin D 1900 I U vitamin A per gram); plus anhydrous $MnSO_4$ 0 0125 g per 100 g of feed.
200		8-12	8	32	Corn ground yellow 31; standard wheat middlings 20; pulverized oat 20; alfalfa meal 7 (meal contains 75,000 or more I. U of vitamin A per pound); wheat bran 4 5; dried whey, 5; fish meal 5; meat meal 5; ground limestone 4; salt 0 5; vitamin A and D feeding oil 0 5 (oil contains 300 International Chick Units vitamin D 1500 I. U vitamin A per gram); crystalline riboflavine 0 2 mg per 100 g of feed; plus anhydrous $MnSO_4$ 0 0125 g per 100 g of feed.
201	Mature				

/1/ The numerals I II III IV occurring occasionally in column D refer to alt rnative dietary mixtures whose compositions are given in column E.

51 ZOO DIETS MAMMALS CARNIVORES

Diets illustrate the feeding practices successfully in use in the New York Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a single specimen of the species listed

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight per Day	Composition of Diet: Horse Meat	Composition of Diet: Horse Liver	Composition of Diet: Horse Kidney
			kg	kg	g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	CARNIVORA							
1	Badger Canadian (Taxidea taxus taxus)		14	5	51			
2	Bear Eurasian brown (Ursus arctos arctos)	M	205	43	30	33		
3	Bear grizzly (U horribilis horribilis)	M	318	54	24	27		
4	Bear kodiak (U middendorffii)	M	364	60	24	32		
5	Bear Malayan sun-bear (Helarctos malayanus)	F	25	7	44	31		
6	Bear polar (Thalarctos maritimus)	M	341	60	25	23		
7	Bear polar (T maritimus)	M	386	83	31			
8	Bear polar (T maritimus)	F	136	50	33	22		
9	Bear spectacled (Tremarctos ornatus)	M	114	41[8]	51			
10	Cat jungle (Felis chaus fulvidina)	F	4	3	107	83	17[10]	
11	Cheetah (Acinonyx jubatus)	M	55	18	47	92	5[10]	
12	Dingo (Canis dingo)[11]	M	23	11	68	10	4[10]	
13	Hyena spotted (Crocuta crocuta)	M	45	8	25	83	6[10]	
14	Jaguar (Panthera onca)	M	80	18	32	86	5	8
15	Jaguar (P onca)	M	80	15	27	91	3[10]	
16	Jaguar (P onca)	F	64	15	33	84	6	9
17	Leopard black (P pardus)	M	45	13	41	88	4	7
18	Lion (P leo)	M	159	27	24	95	3	
19	Lynx Yukon (F lis canadensis mollipilosus)		16	8	71	70		
20	Ocelot (F pardalis)		7	5	100	83	17	
21	Panda lesser (Ailurus fulgens fulgens)		6	9	214			
22	Raccoon (Procyon lotor)		5	3	86	15		
23	Tiger Bengal (Panthera tigris)	M	227	45	28	97	2	
24	Tiger Bengal (P tigris)	F	136	32	34	96	3	
25	Wolf maned (Chrysocyon jubatus)	M	27	12	63		4[10]	
26	Wolf North American (Canis lupus nubilis)	M	36	15	60	15	5[10]	
	PINNIPEDIA							
27	Sea lion (Zalophus californianus)	M	273	6	3			
28	Seal harbor (Phoca vitulina geronimensis)	F	32	13	58			

/1/ Composed of: meat 56% kibbled dog biscuit 14% powdered milk 3% bone meal 3% sodium chloride 1% and water 23% /2/ S D - San Diego Zoological Gardens San Diego California N Y New York Zoological Park New York, N Y Chi - Lincoln Park Zoo, Chicago Ill /3/ Eggs 2% bran and honey mix 3% /4/ Eggs 3% and bran and honey mix 7% /5/ Eggs 14%, and bran and honey mix 20% /6/ During summer total bread allowance increased 2-4 times /7/ Eggs 5% and bran and honey mix 8% /8/ Includes 3

51 ZOO DIETS MAMMALS, CARNIVORES (Concluded)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a single specimen of the species listed

Composition of Diet (concluded)												
Bone Meal	Dog Food Mix[1]	Fowl	Bread	Milk	Butter fish	Mackerel	Fish General	Vegetables	Apples	Fruit, General	Misc	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)
	100											SD
			15			20		23	2	4	5[3]	SD
			14			24		27	3	5	10[4]	SD
			9		23	23			14			NY
								15	10	10	54[5]	SD
			9[6]		46	75						NY
	19		34				46	5				Chi
			8					36	7	16	11[7]	SD
			40						33		27[9]	NY
												SD
		5										SD
	45	8		29							6[12]	SD
		11										SD
1												NY
		6										SD
1												NY
1												NY
1												NY
				26							4[12]	SD
												SD
				18					9	64[13]	9[14]	SD
1	45		10				30					Chi
1												NY
	89	7										NY
												SD
	76	6										SD
					50	25	25[15]					NY
							100					NY

gallons of milk (1 8 kg powdered milk to 11 liters water); conversion of gallons of milk to kilograms made on assumption that 1 liter milk = 1 kg /9/ Milk (see Fn 8) /10/ Combination of horse liver and kidney /11/ Immature animal /12/ Eggs /13/ Includes bananas 36% grapes 9% dates 9% and raisins 9% /14/ Eggs 8%, Pablum 1% /15/ Smelts

Diets illustrate the feeding practices succe sfully in use in the New York, Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a ingle specimen of the species listed.

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight pe Day	Composition of Diet				
						Alfalfa	Browse	Clover	Oat Hay	Timothy
			kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	PRIMATES									
1	Ape celebes crested (Macaca niger)	M	23	14	87					
2	Chimpanzee (Pan troglodytes)	M	61	30	70					
3	Colobus East African (Colobus polykomos kikuyensi)	M	18	14	111					
4	Gorilla (Gorilla gorilla)	F	133	25 [7]	27					
5	Gorilla (G gorilla)	F	32	29 [9]	128					
6	Gorilla (G gorilla)	M	230	87	50					
7	Gibbon (Hylobates lar)	F	9	6	95					
8	Guenon beira (Cercopithecus mitis rythrarchus)	M	1	8	1143					
9	Macaque Burmese pig tailed (Macaca nemestrina andamensi)	F	2	10	715					
10	Macaque Formosan rock (M. cyclopi)	M	1	9	280					
11	Macaque stump-tailed (M. speciosa)	M	25	16	92					
12	Marmoset red handed (Mystax midas)	F	0 4	2	715					
13	Monkey mantled howling (Alouatta palliata aequatorialis)	M	3	5	238			2		
14	Orangutan (Pongo pygmaeus)	M	48	15 [20]	45					
15	Orangutan (P pygmaeus)	M	68	27	57					
16	Saki golden headed (Pithecia pithecia chrysocephala)	M	1	6	857					
	ARTIODACTYLA									
17	Alpaca (Lama pacos) [24]	M	91	20	31	28 [25]	16			
18	Anoa (Anoa depressicorni) [24]	M	102	36	50	40 [25]	15		17	
19	Anoa (A. depressicornis)	F	102	37	52			60	9	
20	Antelope sabl (Hippotragus niger roosevelti) [24]	M	250	99	54	32 [25]	46			
21	Aoudad (Ammotragus l rvi)	M	55	18	47	46 [25]	13			
22	Bison (Bison bison bison)	M	273	139	73		6		92	
23	Blackbuck (Antilope cervicapra) [24]	M	45	13	41	43 [25]	18			
24	Bongo eastern (Boocercus eurycerus isaaci)	F	220	58	38			65		
25	Buffalo African (Syncerus caffer) [24]	M	1636	160	14	85 [25]	7			
26	Camel Bactrian (Camelus bactrianus) [24]	M	841	168	29	57 [25]	8			

/1/ Grain mix feed composed of beet pulp 30%, rolled barley 32%, bran 11% rolled oats 8%, ground corn 11%, linseed meal 4%, bone meal 1%, and salts 1% /2/ S D San Diego Zoological Gardens San Diego California. N Y New York Zoological Park, New York, N Y Chi Lincoln Park Zoo Chicago Ill /3/ Sweet /4/ Other fruits 31% and other vegetables 31% /5/ Other fruits 14%, othe vegetables 20%, rice 5% and milk 5% /6/ Other fruits 27% other vegetables 18%, corn 2%, wheat 1% and rice 1% /7/ Oranges 5%, and other vegetables 12% /8/ Plus tablespoon of cod liver oil and 12 drops of vitamin formula per day /9/ Plus tablespoon of Vi Magna per day /10/ Other fruits 26%, milk 23%, and Pablum 2% /11/ Sweet 8% and Irish 8% /12/ Milk and cream 28% grapes 27% and othe fruit 2% /13/ Other fruits 14% other vegetables 19%. /14/ Other fruits 36%, ther vegetables 24%, rice 3% wheat 3% and corn 3% /15/ Other fruits 30% other vegetables 33%, wheat

Diets illustrate the feeding practices successfully in use in the New York Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a single specimen of the species listed

Composition of Diet (concluded)													
Crushed Oats	Bread	Apples	Avocados	Bananas	Cabbage Lettuce	Carrots	Celery	Potatoes	Horse Meat	Eggs	Grain Mix[1]	Misc	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)
	4	11	6		8	3		3[3]		3		62[4]	SD
	5	14	5	8	19			7[3]				44[5]	SD
	7	9	17		9	3		5[3]		8		50[6]	SD
		10		15	8	33	7		4	3		22[8]	NY
		11	5	11	9				3	3		60[10]	SD
	3	5		4	12	2	5	16[11]				55[12]	CHI
	6	13	6	25	15			6[3]				33[13]	SD
	5	4	7		8			5[3]		4		69[14]	SD
	4	3	7		7	3		4[3]		7		65[15]	SD
	4	3			7			3[3]		7		76[16]	SD
	9	10	5		9	3		3[3]		4		57[17]	SD
		15		50					15			20[18]	NY
	6	19		29	115	7				6		20[19]	NY
	3	11		17	17	28			22	5		2[21]	NY
	4	18	5	3	15			6[3]		5		46[22]	SD
	7	5	1		11	4		4[3]		6		62[25]	SD
			14[24]		7	21					14		SD
			4[24]			8	11				7		SD
	4	3			11	4		9					NY
			5[24]			5	7				5		SD
			8			8	15				11		SD
											2		SD
			11[24]			9	11				9		SD
		8		11		5		5				16[26]	NY
			4[24]								4		SD
			4[24]				8				7		SD

1% and rice 1%. /16/ Other fruits 55% and other vegetables 57% /17/ Other fruits 58%, other vegetables 12% wheat 1%, rice 1% and peanuts 4% /18/ Oranges 80% /19/ Evaporated milk 15%, canned dog food 5%, and grapes 2% /20/ Plus one gallon of milk mixture per day and 4 dog biscuits per day /21/ Grapes 2%. /22/ Other fruits 21%, and other vegetables 75% /23/ Other fruits 34%, other vegetables 82% corn 2%, rice 2% and wheat 2% /24/ Values given are for winter months only; for other seasons eliminate avocados and recalculate values /25/ Values for 10 months of the year; for remaining two months alfalfa pellets in half the quantity are substituted for fresh alfalfa. /26/ OLF formula, composed of: wheat bran 10%, hominy feed and corn meal 20%, 34 per cent linseed oil meal 10%, crushed oats 21%, cane molasses 10%, beet pulp 10%, chopped alfalfa 12%, wheat germ meal 5% Brewer's yeast 4% and salts 2%

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a single specimen of the species listed.

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight per Day	Composition of Diet: Alfalfa	Browse	Clover	Oat Hay	Timothy
			kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	ARTIODACTYLA (concluded)									
27	Camel Dromedary (Camelus dromedarius)	F	595	48	12					
28	Deer Axis (Axis maculatus)[24]	M	73	13	29	46[25]	51			
29	Deer red (Cervus elaphus)[24]	F	159	28	25	49[25]	16			
30	Deer sambar (C unicolor equinus)[24]	M	181	34	25	48[25]	26			
31	Elk (Cervus canadensis canadensis)[24]	M	545	47	[illegible]	46[25]	10			
32	Gayal (Bibos frontalis)	F	455	84	26			57		
33	Gazelle Arabian (Gazella gazella arabica)	M	14	12	122		7	55		
34	Giraffe Uganda (Giraffa camelopardalis rothschildi)	M	1134	222	28	16[25]				
35	Giraffe Uganda (G camelopardalis rothschildi)	F	591	121	29			52		
36	Gnu brindled (Connochaetes taurinus)[24]	M	895	45	22	60[25]	10			
37	Goat tahr (Hemitragus jemlahicus jemlahicus)[24]	M	91	21	33	51[25]	15			
38	Guanaco (Lama huanacho)[24]	M	136	25	26	44[25]	18			
39	Hippopotamus (Hippopotamus amphibius)	M	1909	400	30	28		44		
40	Hippopotamus pygmy (Choeropsis liberiensis)[24]	M	182	116	91	55[25]				
41	Kudu greater (Strepsiceros strepsiceros)[24]	M	455	91	29	45[25]	13			
42	Llama (Lama glama)[24]	M	125	39	45	57[25]	12			
43	Moose (Alces alces andersoni)[24]	M	341	305	128		31			
44	Muntjac Reeves (Muntiacus reevesi)[24]	F	11	9	117	31[25]	15			
45	Nilgai (Boselaphus tragocamelus)[24]	M	273	44	23	62[25]	10			
46	Okapi (Okapia johnstoni)	M	205	70	49			45		
47	Peccary white lipped (Tayassu pecari)	F	14	16	164					
48	Pronghorn (Antilocapra americana)[24]	M	57	18	45	57[25]	12			
49	Sheep Canadian bighorn (Ovis canadensis c)[24]	M	57	18	45	46[25]	12			
50	Sitatunga (Limnotragus spekii)	M	55	18	47			70		
51	Vicuna (Vicugna v mensalis)[24]	M	49	27	86	5[25]	9		61	
52	Warthog (Phacochoerus aethiopicus)	F	55	31	81			52		

/1/ Grain mix feed composed of: beet pulp 50% rolled barley 32% bran 11%, rolled oats 8% ground corn 11% linseed meal 4% bone meal 1%, and salts 1% /2/ S D San Diego Zoological Gardens San Diego California N Y = New York Zoological Park, New York N. Y Chi Lincoln Park Zoo, Chicago Ill /24/ Values are for winter months only; for other seasons eliminate browse and recalculate values /25/ Values are for 10 months of the year; for remaining two months alfalfa pellets in half the quantity are substituted for fresh alfalfa. /26/ GLF formula composed of: wheat bran 10%, hominy feed and corn meal 20% 34 per

Diets illustrate the feeding practices successfully in use in the New York Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a single specimen of the species listed

Composition of Diet (concluded)													
Crushed Oats	Bread	Apples	Avocados	Bananas	Cabbage Lettuce	Carrots	Celery	Potatoes	Horse Meat	Eggs	Grain Mix[1]	Misc.	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)
												100[27]	NY
			9[24]			7					7		SD
			10[24]			10	5				10		SD
			8[24]			6	4				8		SD
			14[24]		12	17					1		SD
	6	1		6	8							22[28]	NY
		9				7		10				1[29]	NY
		16				11		7				50[30]	SD
	8	1		5	7	1		2				24[31]	NY
			9[24]			6	9				6		SD
			6[24]			6	15				9		SD
			11[24]			16					11		SD
												28[26]	NY
	5	5	1[24]		12	12	12	19					SD
		6	8[24]		6	6	9				6		SD
			11[24]			55					7		SD
		22	3[24]		6	9		16[32]			7	21[33]	SD
			6[24]		16	15	15				4		SD
			6[24]			6	9				6		SD
	14	1		14	9	3						24[26]	NY
	5	13		5	20	5		41				11[34]	NY
			8[24]		15	8	12				8		SD
			8[24]			8	15				11		SD
5	5	2		5	4	2		2				5[26]	NY
		10	5[24]								5		SD
15	8	9		5	5	8							NY

...wheat linseed oil meal 10% crushed oats 21%, cane molasses 10% beet pulp 10% chopped alfalfa 12% wheat germ 5% Brewer s yeast 2%, and salts 2% /27/ Timothy 67% GLF formula 33% (see Fn 26) /28/ Crushed oats 11% and GLF formula 11% (see Fn 26) /29/ Rolled oats 5% crushed oats 7%, and grain mix 5% (see Fn 1) /30/ Acacia browse 37%, onions 5% and grain mix 5% (see Fn 1) /31/ Crushed oats 12% and GLF formula 12% (see Fn 26) /32/ For 6 months then replaced by watermelon /33/ Grapes for 6 months then replaced by watermelon /34/ GLF formula 8% (see Fn 26) and meat 2%

52: ZOO DIETS MAMMALS, HERBIVORES (Continued)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a single specimen of the species listed.

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight per Day	Composition of Diet: Alfalfa	Browse	Clover	Oat Hay	Timothy
			kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	PROBOSCIDEA									
53	Elephant African (Loxodonta a. africana)	F	3409	698	29	56				35
54	Elephant African forest (L. cyclotis)	M	2045	579	26	34				50
55	Elephant Indian (Elephas maximus)	F	2500	441	25	56				50
	PERISSODACTYLA									
56	Rhinoceros, black (Diceros bicornis)	M	1275	280	31	25				34
57	Rhinoceros Indian (Rhinoceros unicornis)	F	1591	265	24	34				50
58	Tapir Baird s (Tapirella bairdii)	M	136	112	118	57				
59	Tapir South American (Tapirus terrestris)	F	227	47	30		10			
60	Zebra Chapman s (Equus burchellii (antiquorum)	F	295	47	23				5	68
61	Zebra Grevy s (E. grevyi)	M	409	57	20				15	84
	MARSUPIALIA									
62	Kangaroo red (Macropus rufus rufus)	M	59	22	53			45		
63	Wallaby agile (M. agilis)	F	5	6	200			42		
64	Wombat (Vombatus hirsutus)	F	9	4	65					

/1/ Grain mix feed composed of: beet pulp 32%, rolled barley 32%, bran 11%, rolled oats 8%, ground corn 11% linseed meal 4%, bone meal 1%, and salts 1% /2/ S D = San Diego Zoological Gardens San Diego, California. N Y New York Zoological Park New York, N Y Chi = Lincoln Park Zoo Chicago Ill /26/ CLF

52 ZOO DIETS MAMMALS HERBIVORES (Concluded)

Diets illustrate the feeding practices successfully in use in the New York Chicago and San Diego zoological parks Differences in diet reflect climatic conditions food availability and individual variation within species Body weights are only estimated and the amounts of food eaten are approximate only and are for a single specimen of the species listed

Composition of Diet (concluded)													
Crushed Oats	Bread	Apples	Avocados	Bananas	Cabbage Lettuce	Carrots	Celery	Potatoes	Horse Meat	Eggs	Grain Mix[1]	Misc	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)
3	1				1			2				5[26]	NY
3	2				2			3				5[26]	NY
4	2				2			3					NY
	54				2	2		[illegible]				2[26]	NY
					5			8				5[26]	NY
6	9	5				4		11				6[26]	NY
	12	19	6[24]		12			15[3]			18		SD
19													NY
						3							NY
5	11	7		4	11	4		7				11[35]	NY
	13	9		4	6	11		6				9[35]	NY
12	24	20		8		12		12				12[35]	NY

formula, composed of: wheat bran 10% hominy feed and corn meal 20% 34 per cent linseed oil meal 10% crushed oats 21% cane molasses 10% beet pulp 10% chopped alfalfa 12%, wheat germ meal 5% Brewer s yeast 2%, and salts 2%

53 ZOO DIETS BIRDS

Diets illustrate the feeding practices successfully in use in the New York and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only and are for single [illegible] of the species listed.

	Species	Wt	Total Food per Week	Food per kg Body Weight per Day	Meat	Butter fish	Anchovies and Sardines	Fish, general	Bread	Barley	Rolled oats	Apples	Bananas	Oranges	Fruit, general	Lettuce	Misc	Dep[1]
		kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
	STRUTHIONIFORMES																	
1	Ostrich, North African (Struthio camelus camelus)	114	14	18	24				18	23						83	13[3]	SD
2	Ostrich, South African (S. camelus australis)	64	18[3]	38	6	10			18		13	13				27	14[4]	NY
	CASUARIIFORMES																	
3	Cassowary, Jobi one-wattled (Casuarius unappendiculatus occipitalis)	45	21[5]	67	4							31	15		31		19[6]	SD
4	Cassowary, violet-necked (C. casuarius [illegible])	39	11[7]	40	3	7			57			10	7	14				NY
5	Emu (Dromiceius novaehollandiae)	27	10	33	6				32		11	16				34	11[4]	NY
6	Emu (D. novaehollandiae)	43	14	44	6				18	34		29				34		SD
	PELECANIFORMES																	
7	Pelican, eastern, brown (Pelecanus occidentalis carolinensis)	7	9[8]	179		100												NY
8	Pelican, eastern, white (P. onocrotalus)		8	160			100											SD
10	Pelican, European, white (P. onocrotalus)	6	7[8]	167		100												NY
	Pelican, Peruvian (P. occidentalis thagus)	3	7	800			100											SD
	SPHENISCIFORMES																	
11	Penguin, king (Aptenodytes patagonica)	20	11[9]	79				100[10]										NY
12	Penguin, rock-hopper (Eudyptes crestatus)	3	4	190				100[11]										NY
	CICONIIFORMES																	
13	Adjutant, Indian (Leptoptilos dubius)	8	7	185	14[12]	86												NY
1	Adjutant, Indian (L. dubius)	11	2	165			100											SD
13	Heron, cocoi (Ardea cocoi)	2	1	71		100												NY
16	Shoebill (Balaeniceps rex)	7	4	188		100												NY
17	Shoebill (B. rex)	5	4	880			40										60[13]	SD
	FALCONIFORMES																	
18	Condor, Andean (Vultur gryphus)	23	6	57[14]			100											SD
19	Condor, Andean (V. gryphus)	10	3	71	100													NY
20	Eagle, bald (Haliaeetus leucocephalus washingtoniensis)	3	2	99			100											SD
21	Eagle, southern, bald (H. leucocephalus leucocephalus)	6	3	71	65	35												NY
	CHARADRIIFORMES																	
22	Gull, great, black-backed (Larus marinus)	2	8	143		100												NY
	STRIGIFORMES																	
23	Owl, snowy (Nyctea scandiaca)	1	1	143	100													NY
24	Owl, snowy (N. scandiaca)	1	1	143			100											SD

/1/ NY: New York Zoological Park, New York, N.Y.; SD: San Diego Zoological Gardens, San Diego, California. /2/ Alfalfa. /3/ Supplemented with 1 quart whole corn daily in cold months and 1 quart scratch grain daily in warm months. /4/ [illegible] formula consisting of: wheat bran 10%, hominy feed and corn meal 20%, 34 percent linseed oil meal 10%, crushed oats 21%, [illegible] are 10%, beet pulp 10%, chopped alfalfa 12%, wheat germ meal 3%, brewers' yeast 3%, salts 1%. /5/ Supplemented with 30 mice per week. /6/ Bananas. /7/ Supplemented with 7 rats per week. /8/ Eats about 10% more daily for 2 autumn months. /9/ Penguins eat almost twice as much for two days before and after annual molt; during molt (10-13 days) there is almost complete in[illegible]. /10/ Mackerel. /11/ Smelts. /12/ Rat per week sometimes substituted. /13/ Liver. /14/ 4 rats per month sometimes substituted.

54 REPRESENTATIVE SYNTHETIC DIETS INSECTS

Diets are representative diets for a number of insects which have been extensively studied in nutritional research. Insects maintained on sterile diets arise from eggs rendered bacteria free.

Organism / Nutrient	Orthoptera		Coleoptera	Lepidoptera		Diptera	
	German cockroach (Blattella germanica (L.)) Nymphs and adult	German cockroach (Blattella germanica (L.)) Nymphs and Adult	Mealworm[1] yellow (Tenebrio molitor L.) Larvae	Flour moth (Ephestia sp.) Larvae	Corn borer (Pyrausta nubilalis) Larvae	Fruit fly (Drosophila melanogaster) Larvae	Mosquito yellow fever (Aedes aegypti L.) Larvae
Type of Medium							
	Solid Not Sterile[2]	Solid Sterile[3]	Solid Not Sterile[2]	Solid Not Sterile[4]	Agar Base Sterile[2]	Agar Base Sterile[2]	Liquid and Solid Sterile[4]
	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 ml[5]	per 100 ml[5]
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Proteins Protein Derivatives							
1 Casein[6] g	30.0	27.0	17.0	17.0	4.0		0.6
2 Cystine mg							20.0
3 Glutathione mg							1.0
4 Amino-acid mixture[7] g						2.4	
Carbohydrates							
5 Dextrin g		65.0					
6 Glucose g	51.0		69.0	68.0	4.0		
7 Sucrose g						0.75	0.2
Lipids							
8 Corn oil g	3.0						
9 Soy bean oil g		1.0					
10 Wheat germ oil g				1.0			
11 Cholesterol[8] g	1.0	0.5	0.9	1.0	0.15	0.04	0.005
12 Ergosterol g		0.5					
13 Lecithin g							
14 Linoleic acid g					0.15		
Vitamins and Growth Factors							
15 Biotin mg	0.06	0.025	0.02	0.02		0.005	0.005
16 Cobalamin[9] mg						0.004	
17 Carnitine mg			0.15				
18 Choline[10] mg	400.0	100.0	30.0	50.0	0.06	7.5	2.0
19 Inositol mg	200.0	97.0		50.0			4.0
20 Niacin mg	10.0	10.0	1.6	5.0			0.2

/1/ A diet also suitable for the confused flour beetle (Tribolium confusum) and Palorus ratzeburgi; carnitine is not required by T. confusum. /2/ Supports rapid growth relative to growth on adequate crude diets. /3/ Supports slow growth relative to growth on adequate crude diets. /4/ Supports fair growth relative to growth on adequate crude diets. /5/ Calculated as grams or milligrams/100 grams of diet and figures rounded. /6/ Vitamin free. /7/ A mixture of 18 pure amino-acids. /8/ Cholesterol is an essential substance for all insects which have been critically studied. /9/ Vitamin B_{12}. /10/ As the chloride.

54 REPRESENTATIVE SYNTHETIC DIETS INSECTS (Concluded)

Diets are representative diets for number of insects which have been extensively studied in nutritional research. Insects maintained on steril diets arise from eggs rendered bacteria free.

	Organism / Nutrient	Orthoptera		Coleoptera	Lepidoptera		Diptera	
		German cockroach (Blattella germanica (L.)) Nymphs and adults	German cockroach (Blattella germanica (L.)) Nymphs and adults	Mealworm[1] (Tenebrio molitor) Larvae	Flour moth (Ephestia sp.) Larvae	Corn borer (Pyrausta nubilalis) Larvae	Fruit fly (Drosophila melanogaster) Larvae	Mosquito (Aedes aegypti) Larvae
	Type of Medium	Solid Not Sterile[2]	Solid Sterile[3]	Solid Not Sterile[2]	Solid Not Sterile[4]	Agar Base Sterile[2]	Agar Base Sterile[2]	Liquid and Solid Sterile[4]
		per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 ml[5]	per 100 ml[5]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Vitamins and Growth Factors (concluded)							
41	Niacinamide mg						1.0	1.0
42	Pantothenic acid[11] mg	4.0	10.0	0.8	5.0		0.6	0.6
43	Para-aminobenzoic acid mg		10.0					0.2
44	Pteroylglutamic acid, mg	0.5	0.4	0.0125-0.0250	0.2		0.6	0.06
45	Pyridoxine[12] mg	1.6	10.0	0.2	5.0		0.5	0.4
46	Pyridoxamine[13] mg							0.008
47	Riboflavine mg	1.8	10.0	0.2-0.8	5.0		0.24	0.2
48	Thiamine[12] mg	1.2	10.0	0.1	5.0		0.15	0.2
	Other Nutritional Factors							
49	Brewer's yeast g					1.50		
50	Leaf factor[14] g					1.2		
51	Ribonucleic acid, g		0.5				0.1	0.1
	Minerals							
52	$CaCl_2$[15] mg						1.5	1.2
53	$FeSO_4$[15] mg						1.5	1.2
54	K_2HPO_4[15] mg						61.0	60.0
55	KH_2PO_4[15] mg						61.0	60.0
56	$MgSO_4 \cdot 7H_2O$[15] mg						27.0	20.0
57	$MnSO_4 \cdot 7H_2O$[15] mg						1.5	1.2
58	NaCl[15] mg						1.5	1.2
59	McCollum's mixture 185[16] g			2.0	2.0			
60	U.S.P. No. 1[17] g		5.0					
61	Wesson's mixture[18] g	4.0				0.50		
	Other Ingredients							
62	Agar-agar g					2.5	2.0	
63	Cellulose g	30.0				1.8		
64	Water ml		2.0	9.0		100.0	100.0	100.0

/1/ A diet also suitable for the confused flour beetle (Tribolium confusum) and Palorus ratzeburgi; carnitine is not required by T confusum. /2/ Supports rapid growth relative to growth on adequate crude diets /3/ Supports slow growth relative to growth on adequate crude diets /4/ Supports fair growth relative to growth on adequate crude diets /5/ Calculated as grams or milligrams/100 grams of diet and figures rounded. /11/ As calcium pantothenate /12/ As the hydrochloride /13/ As the dihydrochloride /14/ From Cerophyl Laboratories Inc /15/ Ingredient of Tatum salt mixture for which see Ref 14 /16/ For which see Ref 15. /17/ For which see Ref 16 /18/ For which see Ref 17

55 SELECTED SOURCES FOR CERTAIN NUTRIENTS

Foods listed are important sources of nutrient indicated. Data do not take into account, however, food habit or costs which may lead to use of food stuff not listed as chief source of nutrient. Values in the units specified are per 100 grams of edible portion of uncooked food stuff unless otherwise indicated.

Nutrient (A)	Sources and Nutritive Value (B)
Food energy, Calories[1]	Cheese (except cottage) 300-450 Cooking & table fats, salad oils 700-900 Grain products, dry 330-370 Nuts: treenuts, peanuts 540-700 Salt pork, bacon, other fat meats 600-800 Sugars 370-385
Protein, g	Eggs 13 Grains 6-14 Legumes, mature, dry 21-35 Meat, poultry, fish 16-20 Milk 3-4
Carbohydrate, g	Fruit, dried 67-73 Grains 73-80 Legume, mature, dry (except soybeans) 60-64 Potatoes, sweetpotatoes 19-28 Sugars 90-100
Fat, g	Cheese (except cottage) 25-37 Cooking and table fat, salad oils 81-100 Cream 20-35 Nut 54-73 Salt pork, bacon, other fat meats 55-85
Vitamin A, calc. as β-carotene[2], mg	Butter, margarine with vit. A added 1.9 Carrots 7.2 Greens, all kinds 1.8-5.7 Liver, all kinds 6.5-50.5 Sweetpotatoes 4.6
Ascorbic acid, mg	Various berries[3] 16-60 Cabbage 50 Citrus fruit 40-50 Greens: collards, kale, mustard, turnip 100-136 Potatoes, sweetpotatoes 17-22 Tomatoes 23
Choline, mg	Beans, snap: 340; peas 260 Egg yolk 1130-1700 Liver: 470-700 Peanuts 160-170 Soybeans 300-340; spinach: 240 Wheat germ 400
Cobalamin as vitamin B_{12}[4]	Liver and kidney: high Milk, muscle meats, fish: medium Corn, soybeans, wheat, yeast: low
Vitamin D, calc. as calciferol, μg[5]	Egg yolk, dried 6.6 Fish, canned: pilchard 18.6; salmon 7.9; sardines 34 Fish, raw fresh: herring 7.9; mackerel 28 Liver, all kinds 0.2-1.4 Shrimps 3.8
Tocopherol, mg	Beans, navy, dry 3.6 Butter: 2.4; margarine 34 Eggs, whole 2 Corn oil 87; peanut oil 29; soybean oil 140
Folic acid, μg	Asparagus 89-142; broccoli 34 Beans, navy, dry: 129; corn, sweet 9-70 Cheese, cottage: 21-46 Dates, dry: 25 Greens: collards, kale, mustard, etc. 20-115 Liver: 220-290 Nuts 27-77
Vitamin K, μg	Cabbage, cauliflower: 250-275 Liver, pork: 115-250 Oats 73; soybeans 190 Spinach: 334 Wheat bran: 80
Niacin, mg	Beef, lamb, pork 2.6-5.2 Fish[6], poultry, veal 5.6-10.5 Liver, all kinds 13.7-16.9 Peanuts 16.2 Wheat, other grain products, whole or enriched 2.5
Pantothenic acid, mg	Beans, lima, dry: 0.8 Brains, beef 2.1-2.9 Broccoli 1.4; mushrooms 1.7 Eggs 2.7; liver, beef and pork 5.7-8.2 Peanuts, roasted: 2.5 Wheat bran: 2.4
Pyridoxine, mg	Bananas; cabbage; peanuts, roasted; sweetpotatoes 0.3 Beans, lima, dry: 0.5 Halibut 0.1 Liver, beef 0.8; pork loin: 0.1-0.5 Wheat, whole: 0.2; wheat germ: 0.6
Riboflavine, mg	Eggs 0.3 Greens: collards, kale, turnip: 0.3-0.5 Liver, all kinds 2.5-3.9 Meats, poultry 0.1-0.3 Milk 0.2
Thiamine, mg	Legumes, mature, dry 0.5-1.1 Nuts: treenuts, peanuts 0.2-0.9 Pork 0.5-0.8 Brown rice, rye, corn: 0.3-0.4 Whole wheat, oatmeal 0.4-0.6
Calcium, mg	Cheese: Cheddar type 670-725 Fish, canned with edible bones: 150-400 Greens: collards, kale, mustard, turnip: 200-259 Milk: 118 Soybeans, soy flours 195-265
Iron, mg	Egg yolk: 7.2 Greens: collards, kale, mustard, spinach, turnip: 1.6-3.0 Legumes, mature, dry 4.7-8.0 Liver, all kinds 6.6-18.0 Wheat 3.0-4.3

/1/ Kilocalories. /2/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene or 0.0003 vitamin A alcohol = one I.U. /3/ Include blackberry, blueberry, gooseberry, loganberry, raspberry, strawberry. /4/ Quantitative data not available. /5/ 0.025 μg = one I.U. /6/ Include Atlantic mackerel, halibut, salmon, swordfish.

54 REPRESENTATIVE SYNTHETIC DIETS INSECTS (Concluded)

Diets are representative diets for a number of insects which have been extensively studied in nutritional research. Insect maintained on steril diets arise from eggs rendered bacteria free

Organism	Orthoptera		Coleoptera	Lepidoptera		Diptera	
	German cockroach (Blattella germanica (L.)) Nymphs and adults	German cockroach (Blattella germanica (L.)) Nymphs and adults	Mealworm[1] (Tenebrio molitor) Larvae	Flour moth (Ephestia sp) Larvae	Corn borer (Pyrausta nubilalis) Larvae	Fruit fly (Drosophila melanogaster) Larvae	Mosquito (Aedes aegypti) Larvae
Nutrient	Type of Medium						
	Solid Not Sterile[2]	Solid Sterile[3]	Solid Not Sterile[2]	Solid Not Sterile[4]	Agar Base Sterile[2]	Agar Base Sterile[2]	Liquid and Solid Sterile[4]
	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 ml[5]	per 100 ml[5]
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Vitamins and Growth Factors (concluded)							
Niacinamide mg						1 0	1 0
Pantothenic acid[11] mg	4 0	10 0	0 8	5 0		0 6	0 6
Para-aminobenzoic acid mg		10.0					0.2
Pteroylglutamic acid mg	0 5	0 4	0 0125-0 0250	0 2		0.6	0.06
Pyridoxine[12] mg	1 6	10 0	0.2	5 0		0 3	0 4
Pyridoxamine[13] mg							0.002
Riboflavin mg	1.8	10 0	0 2-0 8	5 0		0.24	0 2
Thiamine[12] mg	1.2	10 0	0 1	5.0		0.15	0 2
Other Nutritional Factors							
Brewers' yeast g					1.50		
Leaf factor[14] g					1.2		
Ribonucleic acid g		0.5				0.1	0.1
Minerals							
$CaCl_2$[15] mg						1.5	1.2
$FeSO_4$[15] mg						1 5	1.2
K_2HPO_4[15] mg						61.0	60 0
KH_2PO_4[15] mg						61.0	60 0
$MgSO_4 \cdot 7H_2O$[15] mg						25.0	20.0
$MnSO_4 \cdot 7H_2O$[15] mg						1.5	1 2
NaCl[15] mg						1 5	1.2
McCollum mixture 185[16], g			2 0	2 0			
U.S.P. No 1[17] g		5 0					
Wesson mixture[18] g	4 0				0 50		
Other Ingredients							
Agar-agar g					2 5	2.0	
Cellulose g	50 0				1.8		
Water ml		2 0	9 0		100 0	100 0	100 0

/1/ A diet also suitable for the confused flour beetle (Tribolium confusum) and Palorus ratzeburgi; carnitine is not required by T confusum. /2/ Supports rapid growth relative to growth on adequate crude diets /3/ Supports slow growth relative to growth on adequate crude diet /4/ Supports fair growth relative to growth on adequate crude diet /5/ Calculated as grams or milligrams/100 grams of diet and figures rounded. /11/ As calcium pantothenate /12/ As the hydrochloride /13/ As the dihydrochloride /14/ From Cerophyl Laboratories Inc /15/ Ingredient of Tatum' salt mixture for which see Ref 17 /16/ For which see Ref 15. /17/ For which see Ref 16 /18/ For which see Ref 14

55 SELECTED SOURCES FOR CERTAIN NUTRIENTS

Foods listed are important sources of nutrient indicated but do not take into account however food habits or costs which may lead to use of foodstuff not listed as chief source of nutrient. Values in the unit specified are per 100 grams of edible portion of uncooked foodstuff unless otherwise indicated

Nutrients (1)	Sources and Nutritive Value (2)
Food energy Calories[1]	Cheese (except cottage) 300-400 Cooking & table fats salad oils 700-900 Grain products dry 330-370 Nuts except chestnuts peanuts 540-700 Salt pork bacon other fat meats 600-800 Sugars 370-395
Protein, g	Eggs 13 Grains 8-14 Legumes and nuts dry 21-35 Meat poultry fish 16-30 Milk 3-4
Carbohydrate g	Fruit dried 67-77 Grains 73-80 Legumes mature dry (except soybeans) 60-63 Potatoes sweetpotatoes 19-28 Sugars 90-100
Fat g	Cheese (except cottage) 25-37 Cooking and table fats salad oils 81-100 Cream 20-35 Nuts 54-73 Salt pork bacon other fat meats 55-85
Vitamin A calc as β-carotene[2] mg	Butter margarine with vit. A added 1 9 Carrots 7 2 Greens all kinds 1.8-5.7 Liver all kinds 8 5-30 3 Sweetpotatoes 4 6
Ascorbic acid mg	Various berries[3] 16-60 Cabbage 50 Citrus fruit 40-50 Greens collards kale mustard turnip 100-136 Potatoes sweetpotatoes 17 22 Tomatoes 25
Choline mg	Beans snap 340; peas 260 Egg yolk 1150-1700 Liver 470-700 Peanuts 160-170 Soybeans 300-340; spinach 240 Wheat germ 400
Cobalamin as vitamin B_{12}[4]	Liver and kidney: high Milk muscle meats fish medium Corn soybeans wheat yeast low
Vitamin D calc as calciferol μg[5]	Egg yolk dried 6 6 Fish canned pilchards 18 6; salmon 7 9; sardines 34 Fish raw fresh herring 7 9; mackerel 26 Liver all kinds 0 2-1.4 Shrimp 3 8
Tocopherol mg	Beans navy, dry 3 6 Butter 2.4; margarine 54 Eggs whole 2 Corn oil 87; peanut oil 22; soybean oil 140
Folic acid μg	Asparagus 89-142; broccoli 54 Beans navy dry 127; corn sweet 9-70 Cheese cottage 21-46 Dates dry 25 Greens collards kale mustard etc 20-119 Liver 220-290 Nuts 27 77
Vitamin K μg	Cabbage cauliflower 250-275 Liver pork 115-250 Oats 75; soybeans 190 Spinach 334 Wheat bran 80
Niacin mg	Beef, lamb pork 2.6-5 2 Fish[6] poultry veal 5.6-10 5 Liver all kinds 13.7 16.9 Peanuts 16.2 Wheat other grain products whole or enriched 2 5
Pantothenic acid mg	Beans lima, dry 0.8 Brains beef 2.1 2.9 Broccoli 1.4; mushrooms 1.7 Eggs 2 7; liver beef and pork 5 7-8 2 Peanuts roasted 2.5 Wheat bran 2 4
Pyridoxine mg	Bananas; cabbage; peanuts roasted; sweetpotatoes 0 3 Beans lima dry 0.5 Halibut 0.1 Liver beef 0.8; pork loin 0.1-0 3 Wheat whole 0.2; wheat germ 0 6
Riboflavine mg	Eggs 0 3 Greens collards kale turnip 0.3-0 5 Liver all kinds 2.5-3 9 Meats poultry 0.1-0 3 Milk 0.2
Thiamine mg	Legumes mature dry 0 5-1.1 Nuts chestnuts peanuts 0 2-0 9 Pork 0 5-0.8 Brown rice rye corn 0 3-0.4 Whole wheat oatmeal 0.4-0 6
Calcium mg	Cheese Cheddar type 670-725 Fish canned with edible bone 150-400 Greens collards kale mustard turnip 220-259 Milk 118 Soybeans soy flours 195-265
Iron, mg	Egg yolk 7.2 Greens collards, kale mustard spinach turnip 1.6-3.6 Legumes mature dry 4 7-8 0 Liver all kinds 6 6-18 0 Wheat 3.0-4 3

/1/ Kilocalories /2/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity 0.0006 mg β-carotene or 0 0003 vitamin A alcohol = one I U /3/ Include blackberry, blueberry gooseberry loganberry raspberry strawberry /4/ Quantitative data not available /5/ 0 025 μg = one I. U. /6/ Include Atlantic mackerel halibut salmon swordfish.

56 BALANCED SALT SOLUTIONS FOR ISOLATED ANIMAL TISSUES

Physiological balanced salt solutions are used for washing cells or tissues and for the dilution of nutrients for various animal cells. In general these salt solutions will support life of isolated animal tissues for a short time, but they are not suitable for long-term maintenance or growth.

	Component \ Solution	Locke	Pannett and Compton	Holtfreter[1]	Tyrode	Parker Glucosal	Baker I[2]	Baker II[3]	Gey I	Gey II	Earle	White[4]	Hanks	Weymouth[4]	Simms[5]
		mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
1	Calcium chloride $CaCl_2$	240	150	100	200	200	172	150	170	130	200		140		111
2	Calcium nitrate $Ca(NO_3)_2 \cdot 4H_2O$											210		200	
3	Ferric nitrate $Fe(NO_3)_3 \cdot 9H_2O$											1.5			
4	Magnesium chloride $MgCl_2 \cdot 6H_2O$		500		214[6]	100	90	75	210	210			100	100	203
5	Magnesium sulfate $MgSO_4 \cdot 7H_2O$								70		200	56.8[6]	100		
6	Potassium chloride KCl	420	600	50	200	200	180	170	370	380	400	375	400	200	200
7	Potassium orthophosphate KH_2PO_4								30	25		26	60	85	
8	Potassium sulfate K_2SO_4														
9	Sodium bicarbonate $NaHCO_3$	500		100	1000		1000	750	2270	250	2200	550	350	560	1010
10	Sodium chloride $NaCl$	9000	4800	5700	8000	8000	7800	5610	7000	8000	6800	7000	8000	7000	8000
11	Sodium orthophosphate mono-H Na_2HPO_4								120	120		57 5[7]	60	57 5	213
12	Sodium orthophosphate di-H $NaH_2PO_4 \cdot H_2O$				57[6]	50	58[6]	45[6]			125				
13	Glucose	1000[8]			1000	1000	1000	2000	1000	1000	1000	8500	1000	6000	1000

/1/ For amphibian tissues. /2/ For fibroblasts and epithelium. /3/ For monocytes. /4/ For use with synthetic media. /5/ X-6 solution for adult fibroblasts. /6/ Quantity of anhydrous salt here specified is calculated from quantity of hydrated salt used in original formulation. /7/ Quantity of hydrated salt here specified is calculated from quantity of anhydrous salt used in original formulation. /8/ Glucose may be omitted from the solution.

Distilled or deionized water should be used wherever possible and the initial volume of the solution should be maintained To avoid serious depletion, the solution is renewed as often as necessary The frequency of renewal depends on the volume of the solution in relation to the mass of growing plant material and environmental conditions

	Compound	Solution	
		Hoagland, D R , and Arnon, D I , 1950[1]	Robbins, W R , 1952[1]
		mg/L	mg/L
	(A)	(B)	(C)
1	H_3BO_3	2 86	0 57
2	$Ca(NO_3)_2 \cdot 4H_2O$	945	1181
3	$CuSO_4 \cdot 5H_2O$	0 08	0 04
4	$FeSO_4 \cdot 7H_2O$[2,3]	5	2 49
5	$MgSO_4 \cdot 7H_2O$	493	493
6	$MnCl_2 \cdot 4H_2O$	1 81	
7	$MnSO_4 \cdot 4H_2O$		1 02
8	$H_2MoO_4 \cdot H_2O$	0 02	0 02
9	$NH_4H_2PO_4$	115	
10	KH_2PO_4		136
11	KNO_3	606	
12	K_2SO_4		348
13	$ZnSO_4 \cdot 7H_2O$	0 22	0 22

/1/ Among other satisfactory solutions are those of Withrow, R B , and Withrow, A P ; Shive, J W , and Robbins, W R , Thimann, K V , and Edmondson, Y H ; Chapman, H D , Brown, S M , and Rayner, D S ; Haas, A R C , Steinberg, R A ; Smith, P F Stewart, W D , Youden, W J , and Arthur, J M /2/ To be added twice weekly or as indicated by the appearance of plants /3/ Equivalent amounts of iron may be supplied as organic iron salts, i e ,iron tartrate or K-Fe-ethylene diamine tetra-acetate

58 CULTURE MEDIA ISOLATED PLANT TISSUES

Values are mg or grams, as specified, per liter of culture solution

Compound \ Tissue and Species	Callus[1]					Embryo[2]		Root Tips[3]		Stem Tips	Tumor	
	Artichoke Jerusalem[4] (Helianthus tuberosus)	Cabbage[5] (Brassica oleracea capitata)	Carrot[6] (Daucus carota)	Hawthorn[7] (Crataegus monogyna)	Tobacco[8] (Nicotiana tabacum)	Cherry sweet[9] (Prunus avium)	Ketelleria[10] (Ketelleria davidiana)	Buckwheat[11 12] (Fagopyrum esculentum)	Tomato[13] (Lycopersicon esculentum)	Asparagus[14] (Asparagus officinalis)	Marigold, African[15 16] (Tagetes erecta)	Sunflower[11,17] (Helianthus annuus)
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
Major Salts												
1 Calcium nitrate $Ca(NO_3)_2 \cdot 4H_2O$, mg	290	290	290	290	140		470	140	480	240	800	290
2 Calcium mono-orthophosphate, $CaH_4P_2O_8$, mg												
3 Calcium sulfate $CaSO_4$, mg	0 2	0 2		0 2		170						
4 Calcium tri-orthophosphate, $Ca_3(PO_4)_2$, mg						170						
5 Ferrous orthophosphate, $Fe_3(PO_4)_2$ mg						170						
6 Ferric sulfate $Fe_2(SO_4 \cdot 6H_2O)_3$, mg	20	20	2 5	20	2 5		1 9[18]	2 5	2 5			2 5
7 Ferric tartrate $Fe_2(C_4H_4O_6)_3$, mg										1 5	5	
8 Magnesium sulfate $MgSO_4 \cdot 7H_2O$, mg	72	72	560	72	72	350	98	74	63	36	720	360
9 Potassium chloride, KCl mg	72	72	65	72	65	680	74	65	42	65	130	65
10 Potassium nitrate, KNO_3 mg	72	72	80	72	80	130	80	80	63	81	160	80
11 Potassium orthophosphate di H, $KH_2PO_4 \cdot H_2O$, mg	72	72		72	12 5		13	12 5	60	20		
12 Sodium orthophosphate, di H, $NaH_2PO_4 \cdot H_2O$, mg			16 5								130	16 5
13 Sodium sulfate, Na_2SO_4, mg			200								100	200

	Minor Salts												
14	Boric acid H_3BO_3 mg			1 5	0 02	1 6			1 5	0 1		3 0	1 5
15	Manganese sulfate $MnSO_4$ $4H_2O$ mg	0 4	0 4	4 5	0 4	4 4			4 5			4 5	4 5
16	Potassium iodide, KI, mg			0 8		0 8			0 8			0 4	0 8
17	Zinc sulfate, $ZnSO_4$ $7H_2O$, mg	0 2[19]	0 2[19]	1 5	0 2[19]	1 5			1 5	0 1		3 0	1 5
	Carbohydrates and Vitamins												
18	Glucose g	20	20		50		5						
19	Sucrose g			20		20		20	20	20	10	20	20
20	Ascorbic acid, mg							10					
21	Folic acid, mg		10										
22	Niacin, mg					0 5		1 0					1 0
23	Pyridoxine, mg					0 5		0 1		0 2		0 8	0 1
24	Thiamine mg					0 1		0 1		0 2		0 1	0 1
	Other Compounds												
25	Adenine sulfate, mg					40[20]							
26	Agar, g	12	12	8	12	7	6 5	6			5	6 0	7
27	Calcium pantothenate mg				1 0								
28	Coconut milk, g			150									
29	Glycine mg			3		2						12	3
30	Indoleacetic acid mg	0 1		0 01-10				10					
31	Naphthaleneacetic acid mg		0 1		0 3								
32	Yeast extract mg								100				

/1/ Additional media for callus tissue, other than those presented in table, have been reported by G Morel; G Morel and R H Wetmore; P Nobecourt; P Nebecourt and L. Kofler; J P Nitsch; L. Duhamet; E. Ball; R. J Gautheret; A C Hildebrandt and A J Riker; L. G Nickell, P Greenfield and P R Burkholder /2/ Additional media for embryo tissue, other than those presented in table have been reported by J Bonner and D Bonner; J van Overbeek M. F Conklin, and A. F Blakeslee /3/ Additional media for root tip culture other than those presented in table, have been reported by P R. White; W G Boll and H E Street; K. J Dormer and H E Street; H E. Street and J S Lowe; J Bonner; J Bonner and F Addicot; J Bonner and P S Devirian; J E McClary; V Slankis /4/ Medium reported by P Nobecourt Also applicable to salsify (Tragopogon porrifolius and Scorzonera hispanica) /5/ Medium reported by R J Gautheret Also applicable to Jerusalem artichoke (Helianthus tuberosa), carrot (Daucus carota), chicory (Cichorium intibus), salsify (Tragopogon porrifolius) /6/ Medium reported by S M. Caplin and F C Steward /7/ Medium reported by G Morel. /8/ Medium reported by F Skoog and C Tsui /9/ Medium reported by H B Tukey Also applicable to sour cherry (Prunus cerasus), peach (P persica), plum (P americana), apple (Pyrus malus), pear (P communis) /10/ Medium reported by S Loo and F H Wang Also applicable to pine (Pinus yunnanensis) /11/ Medium reported by P R. White /12/ Also applicable to many other plants including radish (Raphanus sativus), tobacco (Nicotiana tabacum), tomato (Lycopersicon esculentum), various legumes /13/ Medium reported by W J Robbins and M. B Schmidt /14/ Medium reported by S Loo Also applicable to dodder (Cuscuta campestris) /15/ Medium reported by A C Hildebrandt, A. J Riker, and B M. Duggar Also applicable to sunflower (Helianthus annuus) /16/ Additional media for tumor tissue, other than those presented in table, have been reported by A C Hildebrandt et al /17/ Also applicable to many other plants including Jerusalem artichoke (Helianthus tuberosa), Marguerite chrysanthemum (Chrysanthemum frutescens), carrot (Daucus carota) /18/ The original medium was reported as 1 6 mg $FeCl_3$ /19/ Additional minor salts consist of 0 01 mg each of $CuSO_4$, $NiCl_2$ and $CoCl_2$; 0 8 mg $Ti_2(SO_4)_3$ /20/ Unnecess for growth but promotes formation of buds

59 CULTURE MEDIA FUNGI

Fungi require oxygen obtainable from gas dissolved in the culture medium, or in the case of surface growth from the atmosphere An organic source of carbon is required Most species can utilize ammonium nitrogen and many also nitrate nitrogen. An occasional species may be unable to synthesize a specific amino acid. Most fungi can synthesize all vitamins they require

	Constituents \ Organism	Aspergilli and Penicillia[1]	Basidiomycetes Wood Rotting Types[2]	Neurospora[3]	Saccharomyces cerevisiae (Certain Strains)[4]
		mg/liter	mg/liter	mg/liter	mg/liter
	(A)	(B)	(C)	(D)	(E)
	Salts				
1	Ammonium molybdate $(NH_4)_6Mo_7O_{24}\cdot4H_2O$		0 018		
2	Ammonium nitrate NH_4NO_3			1 000	
3	Ammonium orthophosphate, di-H $NH_4H_2PO_4$				6 000
4	Ammonium tartrate $(NH_4)_2C_4H_4O_6$			5 000	
5	Boric acid H_3BO_3		0 57	0 057	
6	Calcium chloride $CaCl_2$			100	
7	Copper sulfat $CuSO_4\ 5H_2O$		0 059	0 397	0.097
8	Ferric chloride $FeCl_3\cdot6H_2O$			0 960	0 72
9	Ferrous sulf te $FeSO_4\ 7H_2O$	10	0.19	0 980[5]	
10	Magnesium sulfate $MgSO_4\ 7H_2O$	500	500	500	250
11	Manganese chloride $MnCl_2\ 4H_2O$		0 056	0 072	
12	Potassium chloride KCl	500			
13	Potassium orthophosphate mono-H, K_2HPO_4	1 000			
14	Potassium orthophosphate di-H, KH_2PO_4		1 500	1 000	200
15	Sodium chloride NaCl			100	
16	Sodium molybdate Na_2MoO_4			0 042	
17	Sodium nitrate $NaNO_3$	5 000			
18	Zinc chloride $ZnCl_2$			4 2	
19	Zinc sulfate $ZnSO_4\ 7H_2O$		0 31	8 8[6]	1.8
	Carbohydrates				
20	Glucose		10 000		10 000
21	Sucrose	50 000		15 000	
	Amino Acids				
22	Asparagine				2 500
23	Glutamic acid		1,260[8]		
	Vitamins[7]				
24	Biotin			0 005	0 02
25	Pyridoxine-HCl				1 0
26	Thiamine-HCl		1.00[9]		4 0
	Other Constituents				
27	Calcium pantothenate				0 5
28	Sodium citrate				1,000

/1/ Dox' modification of Czapek s medium. /2/ Minimal medium for shake culture /3/ Medium for wild type strains /4/ Variation in strains and cultural conditions require variation in composition of solution. See bibliographic reference /5/ May be substituted for constituent 8D. /6/ May be substituted for constituent 18D. /7/ Certain strains of Saccharomyces cerevisiae require also nicotinamide and para-aminobenzoic acid. /8/ Same amount of asparagine may be used in place of glutamic acid /9/ Thiamine required by most but not all wood rotting basidiomycetes Some require biotin and/or riboflavine

60 CULTURE MEDIA: ALGAE

The atmosphere provides sufficient carbon for growth of most species in light. In laboratory cultures however, most species give better rates and yields of growth if 1-5% CO_2 in air is bubbled through the culture. For those algae that can be cultivated in darkness an organic source of carbon must be provided. Oxygen is utilized from the atmosphere. Water serves as the source of hydrogen and as a sufficient source also of oxygen in the case of many blue-green algae which are capable of good growth under anaerobic conditions even if sulfide is present. Beneficial use of such chelating agents as ethylenediaminetetraacetic acid (EDTA) will permit the safe use of micronutrients in greater concentration, and often improve growth significantly.

	Compound / Medium	General[1]	Myers[2,3]	Allison[4]	Emerson Lewis[5]	Chu No. 10[5]	Allen[5,6]	Artificial Sea Water[7]
		mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1	Ammonium chloride NH_4Cl				5		5	
2	Ammonium metavanadate NH_4VO_3	0.0023[8]	0.0023[8]	0.0023[8]	0.0023[8]	0.0023[8]	0.0023[8]	
3	Boric acid H_3BO_3	0.286[9]	0.286[9]	0.286[9]	0.286[9]	0.286[9]	0.286[9]	
4	Calcium chloride $CaCl_2$	4-40			2		5	
5	Calcium nitrate, $Ca(NO_3)_2$					4		
6	Calcium sulfate, $CaSO_4$			10[10]				100
7	Chromic potassium sulfate $Cr_2K_2(SO_4)_4 \cdot 24H_2O$	0.019[8]	0.019[8]	0.019[8]	0.019[8]	0.019[8]	0.019[8]	
8	Citric acid $C_6H_8O_7$							
9	Cobalt nitrate(ous) $Co(NO_3)_2 \cdot 6H_2O$	0.0049[8]	0.0049[8]	0.0049[8]	0.0049[8]	0.0049[8]	0.0049[8]	
10	Copper sulfate $CuSO_4 \cdot 5H_2O$	0.0079	0.0079[9]	0.0079[9]	0.0079[9]	0.0079[9]	0.0079[9]	
11	Ferric chloride $FeCl_3$	1.2		0.5				
12	Ferric citrate					0.3		
13	Ferric sulfate $Fe_2(SO_4)_3$		5					
14	Ferrous sulfate $FeSO_4$				0.4		Trace	
15	Magnesium chloride $MgCl_2$							370-500
16	Magnesium sulfate $MgSO_4 \cdot 7H_2O$	10-40	250	20	25	2.5	25	170-500
17	Manganese chloride $MnCl_2 \cdot 4H_2O$	0.181[9]	0.181[9]	0.181[9]	0.181[9]	0.181[9]	0.181[9]	
18	Molybdenum oxide MoO_3	0.0015[8]	0.0015[8]	0.0015[8]	0.0015[8]	0.0015[8]	0.0015[8]	
19	Nickel sulfate $NiSO_4 \cdot 6H_2O$	0.0048[8]	0.0048[8]	0.0048[8]	0.0048[8]	0.0048[8]	0.0048[8]	
20	Potassium chloride KCl							70-1000
21	Potassium nitrate KNO_3	20-100	120		100			
22	Potassium orthophosphate, mono-H K_2HPO_4	10-40		50		1	25	
23	Potassium orthophosphate, di-H KH_2PO_4		120		100			
24	Sodium carbonate, Na_2CO_3				150	2		
25	Sodium chloride $NaCl$			20				2600-3000
26	Sodium citrate		20					
27	Sodium metasilicate Na_2SiO_3					2.5		
28	Sodium nitrate $NaNO_3$						100	
29	Sodium tungstate $Na_2WO_4 \cdot 2H_2O$	0.0017[8]	0.0017[8]	0.0017[8]	0.0017[8]	0.0017[8]	0.0017[8]	
30	Titanium oxysulfate $TiOSO_4$	0.005[8]	0.005[8]	0.005[8]	0.005[8]	0.005[8]	0.005[8]	
31	Zinc sulfate $ZnSO_4 \cdot 7H_2O$	0.0022[9]	0.0022[9]	0.0022[9]	0.0022[9]	0.0022[9]	0.0022[9]	

/1/ The ranges of the concentrations of compounds as given in column B include the quantities specified for the media of Knop, Benecke, Molisch, Miquel, and Beijerinck. These have been widely used for cultivation of relatively hardy green and other algae. Differences between these media are probably not significant for most purposes. $Ca(NO_3)_2$ or NH_4NO_3 may be substituted for KNO_3 (a few algae require ammonia nitrogen); KH_2PO_4 may be substituted for K_2HPO_4 for those algae which prefer an acidic environment; $CaSO_4$ may be used instead of $CaCl_2$, and $FeSO_4$ may replace $FeCl_3$. Addition of 0.1% glucose and 0.2% beef extract is useful for maintenance of stock cultures. For marine algae natural sea water or artificial sea water (cf. column H) may be used with the medium. /2/ Medium is excellent for the widely-grown Chlorella. pH adjusted to 4.5-6.8. $MgSO_4 \cdot 7H_2O$ may be reduced to 50 to prevent precipitation on autoclaving. Carbon is best provided by passing 5% CO_2 in air through the culture. /3/ Similar media, e.g., Warburg's and Emerson's are available in the literature (ref. 10, 11). /4/ Used in the cultivation of the nitrogen-fixing algae. Drewes' medium which is similar is available in the literature (ref. 8). /5/ Used for the cultivation of planktonic algae (blue-green, greens, diatoms). Similar media, e.g., Richter's, Pringsheim's, and Harder's are available in the literature (ref. 2). /6/ The addition of 100 mg/100 ml sodium glutamate is desirable for some algae. /7/ The formula includes various artificial sea water media, e.g., Ferrier's, Herbst, and Pringsheim's. /8/ Not specified as part of named solution, but added as a component of Arnon's micronutrient solution B7 for beneficial effect on growth. /9/ Not specified as part of named solution, but added as a component of Arnon's micronutrient solution A5 for possible beneficial effect on growth. /10/ Also: 100-500 mg/100 ml, $CaCO_3$.

61 CULTURE MEDIA: CERTAIN BACTERIA

Values are mg of the nutrient per liter of culture solution.

	Components (A)	Bacillus subtilis mg/L (B)	Haemophilus parainfluenzae mg/L (C)	Lactobacillus arabinosus[1] mg/L (D)	L. arabinosus strain 17 5[2] mg/L (E)	L. lactis mg/L (F)	L. leichmannii mg/L (G)	L. leichmannii strains 313 and 327 mg/L (H)	Leuconostoc citrovorum strain 8081 mg/L (I)	Streptococcus faecalis mg/L (J)
	Amino acids[3]									
1	Alanine		1 000	1 000	100	200	200	100	100	300
2	Arginine HCl		400	400	100	400	200	100	200	400
3	Asparagine	2,000			400	400	200		400	500
4	Aspartic acid		1,000	1 000	400	200	200	400	100	500
5	Cysteine						800	400[4]	50	
6	Cystine		200	200	200	400	400			200
7	Glutamic acid	2,000	2 000	2 000	400	400	400	400	500	1,000
8	Glutamine						100			
9	Glycine		100	100	100	200	500	100	100	100
10	Histidine.HCl		200	200	100	200	200	100	50	200
11	Hydroxyproline						50			
12	Isoleucine		200	200	100	200	500	100	125	200
13	Leucine		200	200	100	400	100	100	125	200
14	Lysine.HCl		400	400	200	400	600	200	200	400
15	Methionine		200	200	100	200	100	100	50	200
16	Norleucine						200			
17	Phenylalanine		200	200	50	200	500	50	50	200
18	Proline		200	200	50		400	50	100	400
19	Serine		200	200	50	200	100	50	25	500
20	Threonine		200	200	100	200	100	100	100	200
21	Tryptophan		200	200	100	400	50	100	20	200
22	Tyrosine		200	200	100	400	400	100	100	200
23	Valine		200	200	100	200	200	100	125	200
	Vitamins									
24	D-Biotin	0.02	0.001	0.01	0.01	0.005	0.005	0.01	0.01	0.01
25	Choline Cl	10	5							
26	Cobalamin					0.004	0.01	0.002		
27	Folacin	0.02	0.01	0.01	0.01	0.005	0.075	0.01	0.01	0.02
28	i-Inositol	10	20							
29	Niacin	2	0.5	1	1	4	1	1	1	1
30	DL-Ca-pantothenate	4	1	1	0.5	2	1	0.5	0.5	0.5
31	Pantethine[5]					200				
32	Para-aminobenzoic acid	0.02	0.001	0.2	0.1	2	0.04	0.1	0.1	0.2
33	Pyridoxine.HCl	2	2		0.5		2	0.5	1	0.5
34	Pyridoxamine.HCl	2					0.4			0.5
35	Pyridoxal.HCl			0.2	0.5		2	0.5	0.5	
36	Pyridoxal phosphate					1	1			
37	Riboflavine	4	0.1	1	0.5	2	1	0.5	0.5	0.5
38	Thiamine HCl	4	1	1	0.5	10	1	0.5	0.5	0.5
	Salts[6]									
39	$CaCl_2$		5			100				
40	$FeCl_3$	20								
41	$FeSO_4$		7	20	5.5	5.5	5.5	5.5	5.5	15
42	KCl	400								
43	KCN					0.25				
44	KH_2PO_4		5,120		500	500	2 000	500	600	
45	K_2HPO_4			5,000	500	500	2 000	500	600	5,000

/1/ The medium given is also suitable for L. casei, L. delbrueckii, L. fermenti, L. brevis (l-arabinose is to be substituted for glucose), and Leuconostoc mesenteroides. /2/ The medium given is also suitable for Leuconostoc mesenteroides strain P-60 (aspartic acid is to be substituted for asparagine) and Streptococcus faecalis strain R. /3/ Values given are for DL-isomers. For the L isomer forms one-half the amount indicated is used. /4/ As cysteine hydrochloride. /5/ N-(pantothenyl)-β-aminoethane disulfide. /6/ Anhydrous salts or comparable quantity of salts incorporating water in the molecule.

61 CULTURE MEDIA CERTAIN BACTERIA (Concluded)

Values are mg of the nutrient per liter of culture solution

Components \ Organism	Bacillus subtilis	Hemophilus parainfluenzae	Lactobacillus arabinosus[1]	L. arabinosus strain 17-5	L. casei	L. leichmannii	L. leichmannii strains 313 and 327	Leuconostoc citrovorum strain 8081	Streptococcus faecalis
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Salts[6] (concluded)									
$MgSO_4$	300	40	370	98	98	684	98	98	250
$MnSO_4$	15		67	1.8	6.8	205	21.8	10.9	50
NaCl	500		40	10	10		10	10	15
Na_2SO_4	4,000								
NH_4Cl		280	3,000					50	2,500
$(NH_4)_2HPO_4$	8,000								
$ZnCl_2$	10								
Carbohydrates									
Glucose		1,000	70,000	20,000	10,000	20,000	20,000	25,000	20,000
Sucrose	100,000								
Purines and Pyrimidines									
Adenine sulfate	40	10	10	10	10	5	10	10	10
Cytidylic acid						10			
Guanine HCl	40	10	10	10	10	5	10	10	
Uracil	40	10	10	10	10	5	10	10	
Uridine									0.2
Xanthine	40		10	10	10	8	10	10	
Other Compounds									
Citric acid	2,000								
Sodium acetate		6,000	1,000	20,000	6,000	5,600	20,000	20,000	5,000
Sodium citrate			20,000			5,000			5,000
Sodium ethyl oxalacetate					500	100			
Glutathione									20
Coenzyme I		0.1[7]							
Tween 80					100	1	1,000		10
Putrescine		500							
Reticulogen[8]								0.4[9]	

/1/ The medium given is also suitable for L. casei L. delbrueckii L. fermenti L. brevis (L-arabinose is to be substituted for glucose) and Leuconostoc mesenteroides /2/ The medium given is also suitable for Leuconostoc mesenteroides strain P-60 (aspartic acid is to be substituted for asparagine) and Streptococcus faecalis strain R. /6/ Anhydrous salts or comparable quantity of salts incorporating water in the molecule /7/ Added aseptically to medium. /8/ A product of Eli Lilly Company /9/ [illegible] ml per liter of medium.

62 CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION INORGANIC FERTILIZERS

Values, with the exception of those for neutralizing action, are grams per 100 grams of air-dry fertilizer material It should be understood that values for neutralizing action are approximate only and their validity is questionable under working conditions

	Fertilizer Material	Elements[1]						Neutralizing Action	
		Calcium[2]	Magnesium[3]	Nitrogen[4]	Phosphorus[5]	Potassium[6]	Sulfur[7]	Acidifying Action	Alkalinizing Action
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	Units[8]	Units[9]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Nitrogen Materials								
1	Ammonia, anhydrous			82				148	
2	Ammonia solution[10]			20 6-24 7				37-44	
3	Ammonium chloride			24 0				128	
4	Ammonium nitrate			33 34				60	
5	Ammonium sulfate			20 5			23 6	110	
6	Calcium cyanamide[11]	39		21 0			0 4		63
7	Calcium ammonium nitrate[12]	7 1 14 3	0-4 5	20 5				0	0
8	Calcium nitrate	20 0		15 5					21
9	Calcium nitrate urea[13]	9 3		34				28	
10	Sodium nitrate			16 0					29
11	Urea[14]			42				75	
12	Urea-ammonia liquor			46				82	
	Phosphorus Materials[15]								
13	Basic slag, Bessemer[16]	34	2 4		7 0		0 2		+17
14	Basic slag open hearth	32	3 0		2 2-6 5		0 2		+17
15	Phosphate rock defluorinated[18]	20 0-30			7 9-10 5				+17
16	Phosphoric acid, liquid				23 6		1 4[19]	+20	
17	Superphosphate, double[21]	12 1-14 3	0 3		18 8-21 4		1 0[22]	0	0
18	Superphosphate, ordinary[23]	17 9-21 4	0 3		6 1-8 7		11 2 12 4	0	0
	Potassium Materials								
19	Alunite, calcined[24]	2 9	0 3			4 6	2 0		
20	Kainite	0 4-3 6	0-9 0			10 0-18 3	0 4-10 0	0	0
21	Manure salts	0-0 7	0-3 6			20 8-33	0-5 2	0	0
22	Potassium carbonate					54	0 2		+17
23	Potassium chloride	0-2 1	0-1.8			40-51	0-2 8	0	0

24	Potassium magnesium sulfate	0-4 6	3 6 11 8			17 4 24 9	12 8-22 4	0	0
25	Potassium sulfate	0-1 8	0-1 2			40-43	15 6-19 2	0	0
	Nitrogen Phosphorus Materials								
26	Ammoniated superphosphate, double	11 8-13 9	0 3	4 0-6 0	18 5-21 2		1 0[22]	11-14	
27	Ammoniated superphosphate, ordinary[4]	17 2 20 7	0 3	2 0-5 0	5 9-8 5		10 8-12 0	4-7	
28	Monoammonium phosphate[25,26]	1 1	0 3	11 0	20 9		2 4	55	
29	Monoammonium phosphate ammonium sulfate[26,27]	0 4		16 0	8 7		15 4	86	
30	Urea superphosphate			7 0	6 5			13	
	Nitrogen-Potassium Materials								
31	Potassium ammonium chloride[28]			13 0		18 5		70	
32	Potassium nitrate	0 4	0 5	13 0		37			23
33	Sodium potassium nitrate			15 0		12 5			26
	Nitrogen-Phosphorus-Potassium-, and Phosphorus-Potassium Materials								
34	Ammonium potassium phosphate			5 5	23 6	15 4		±20	
35	Monopotassium phosphate				22 8	29		0	0
36	Potassium metaphosphate	0 4			24 0	32		0	0

/1/ Data represent the total amount present, with the exception of phosphorus and potassium (cf Fn 5,6) /2/Calcium x 1 3992 = calcium oxide, CaO /3/Magnesium x 1 6579 = magnesium oxide, MgO /4/Nitrogen x 6 0683 = sodium nitra e /5/Data applicable to available phosphorus, i e , amount of phosphorus soluble in water or in salts or acids Phosphorus x 2.2914 = phosphorus pentoxide, P_2O_5 /6/ Data applicable to water-soluble potassium Potassium x 1 2046 = potassium oxide, K_2O /7/ Sulfur x 2 4969 = sulfur trioxide, SO_3 /8/ Grams of calcium carbonate, $CaCO_3$, required to neutralize the soil acidity resulting from the use of 100 grams of the fertilizer material /9/ Grams of calcium carbonate that correspond in acid neutralizing power to 100 grams of the fertilizer material That is, a material having an alkalinizing action of 63 e.g , calcium cyanamide, indicates that 100 grams of this material applied to the soil would be equivalent to 63 grams of calcium carbonate for neutralizing soil acidity /10/ Includes ammonium hydroxide, aqua ammonia, ammonia liquor, "B liquor /11/ Also known as Cyanamid, lime-nitrogen, Nitrolime /12/ Also known as A N L The material is a mixture of ammonium nitrate with either precipitated calcium carbonate, ground high-calcium limestone or ground dolomitic limestone /13/ Also known as Calurea /14/ Also known as Uramon Data applicable to U S /15/ Data for composition of phosphate rocks are not presented because responses of crop plants to application of ground phosphate rock are extremely variable /16/ Also known as Thomas slag, Thomas phosphate, Thomas meal /17/ The material is basic /18/ Also known as defluorinated phosphate, fused phosphate rock, fused tricalcium phosphate, alpha-phosphate /19/ Value applicable to the sulfuric acid process Very little sulfur is present in phosphoric acid manufactured by the electric furnace process /20/ The material is acidic /21/ Also known as triple superphosphate, concentrated superphosphate /22/ Value applicable to material prepared with phosphoric acid manufactured by the sulfuric acid process Very little sulfur is present in material prepared with phosphoric acid manufactured by the electric furnace process /23/ Standard or normal superphosphate /24/ Composition varies widely /25/ Also known as Ammo-Phos A /26/ Data applicable to material made with phosphoric acid manufactured by the sulfuric acid process A higher purity is found in material prepared with phosphoric acid manufactured by the electric furnace process /27/ Also known as Ammo-Phos B /28/ Also known as Potazote

62 CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION INORGANIC FERTILIZERS

Values, with the exception of those for neutralizing action, are grams per 100 grams of air dry fertilizer material It should be understood that values for neutralizing action are approximate only and their validity is questionable under working conditions

	Fertilizer Material	Elements[1]						Neutralizing Action	
		Calcium[2]	Magnesium[3]	Nitrogen[4]	Phosphorus[5]	Potassium[6]	Sulfur[7]	Acidifying Action	Alkalinizing Action
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	Units[8]	Units[9]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Nitrogen Materials								
1	Ammonia, anhydrous			82				148	
2	Ammonia solution[10]			20 6-24 7				37-44	
3	Ammonium chloride			24 0				128	
4	Ammonium nitrate			33 34				60	
5	Ammonium sulfate			20 5			23 6	110	
6	Calcium cyanamide[11]	39		21 0			0 4		63
7	Calcium ammonium nitrate[12]	7 1-14 3	0-4 5	20 5				0	0
8	Calcium nitrate	20 0		15 5					21
9	Calcium nitrate-urea[13]	9 5		34				28	
10	Sodium nitrate			16 0					29
11	Urea[14]			42				75	
12	Urea ammonia liquor			46				82	
	Phosphorus Materials[15]								
13	Basic slag, Bessemer[16]	34	2 4		7 0		0 2		+17
14	Basic slag open hearth	32	3 0		2 2 6 5		0 2		+17
15	Phosphate rock, defluorinated[18]	20 0-30			7 9 10 5				+17
16	Phosphoric acid liquid				23 6		1 4[19]	+20	
17	Superphosphate, double[21]	12 1-14 3	0 3		18 8-21 4		1 0[22]	0	0
18	Superphosphate, ordinary[23]	17 9 21 4	0 3		6 1-8 7		11 2-12 4	0	0
	Potassium Materials								
19	Alunite, calcined[24]	2 9	0 3			4 6	2 0		
20	Kainite	0 4-3 6	0-9 0			10 0-18 3	0 4 10 0	0	0
21	Manure salts	0-0 7	0-3 6			20 8-33	0-3 2	0	0
22	Potassium carbonate					54	0 2		+17
23	Potassium chloride	0-2 1	0-1 8			40-51	0-2 8	0	0

24 Potassium magnesium sulfate	0-4 6	3 6-11 8			17 4 24 9	12 8-22 4	0	0
25 Potassium sulfate	0-1 8	0-1 2			40-43	15 6-19 2	0	0
Nitrogen Phosphorus Materials								
26 Ammoniated superphosphate, double	11 8-13 9	0 3	4 0-6 0	18 3-21 2		1 0[22]	11-14	
27 Ammoniated superphosphate, ordinary	17 2 20 7	0 3	2 0 3 0	3 9-8 3		10 8-12 0	4-7	
28 Monoammonium phosphate[25,26]	1 1	0 3	11 0	20 9		2 4	33	
29 Monoammonium phosphate-ammonium sulfate[26,27]	0 4		16 0	8 7		15 4	86	
30 Urea superphosphate			7 0	6 5			13	
Nitrogen Potassium Materials								
31 Potassium ammonium chloride[28]			13 0		18 3		70	
32 Potassium nitrate	0 4	0 3	13 0		37			23
33 Sodium potassium nitrate			15 0		12 5			26
Nitrogen-Phosphorus-Potassium-, and Phosphorus-Potassium Materials								
34 Ammonium potassium phosphate			5 5	23 6	15 4		±20	
35 Monopotassium phosphate				22 8	29		0	0
36 Potassium metaphosphate	0 4			24 0	32		0	0

/1/ Data represent the total amount present, with the exception of phosphorus and potassium (cf Fn 5 6) /2/ Calcium x 1 3992 = calcium oxide, CaO /3/ Magnesium x 1 6579 = magnesium oxide, MgO /4/ Nitrogen x 6 0683 = sodium nitrate /5/ Data applicable to available phosphorus, i e amount of phosphorus soluble in water or in salts or acids Phosphorus x 2 2914 = phosphorus pentoxide, P_2O_5 /6/ Data applicable to water-soluble potassium Potassium x 1 2046 = potassium oxide, K_2O /7/ Sulfur x 2 4969 = sulfur trioxide, SO_3 /8/ Grams of calcium carbonate $CaCO_3$, required to neutralize the soil acidity resulting from the use of 100 grams of the fertilizer material /9/ Grams of calcium carbonate that correspond in acid neutralizing power to 100 grams of the fertilizer material That is, a material having an alkalinizing action of 63, e.g , calcium cyanamide, indicates that 100 grams of this material applied to the soil would be equivalent to 63 grams of calcium carbonate for neutralizing soil acidity /10/ Includes ammonium hydroxide, aqua ammonia, ammonia liquor, B" liquor /11/ Also known as Cyanamid, lime-nitrogen, Nitrolime /12/ Also known as A N L The material is a mixture of ammonium nitrate with either precipitated calcium carbonate, ground high-calcium limestone or ground dolomitic limestone /13/ Also known as Calurea /14/ Also known as Uramon Data applicable to U S /15/ Data for composition of phosphate rocks are not presented because responses of crop plants to application of ground phosphate rock are extremely variable /16/ Also known as Thomas slag, Thomas phosphate, Thomas meal /17/ The material is basic /18/ Also known as defluorinated phosphate, fused phosphate rock, fused tricalcium phosphate, alpha-phosphate /19/ Value applicable to the sulfuric acid process Very little sulfur is present in phosphoric acid manufactured by the electric furnace process /20/ The material is acidic /21/ Also known as triple superphosphate, concentrated superphosphate /22/ Value applicable to material prepared with phosphoric acid manufactured by the sulfuric acid process Very little sulfur is present in material prepared with phosphoric acid manufactured by the electric furnace process /23/ Standard or normal superphosphate /24/ Composition varies widely /25/ Also known as Ammo-Phos A. /26/ Data applicable to material made with phosphoric acid manufactured by the sulfuric acid process A higher purity is found in material prepared with phosphoric acid manufactured by the electric furnace process /27/ Also known as Ammo-Phos B /28/ Also known as Potazote

63 CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION ORGANIC FERTILIZERS

Values with the exemption of those for neutralizing action are grams pe 100 grams of ai -dry fertilizer material It should be understood that although these values are regarded as typical, wide variation is to be expected in the composition. Values for neutralizing action are approximate only and t_eir validity is questionable under working conditions

	Fertilizer Material	Elemental						Neutralizing Action	
		Calcium[2]	Magnesium[3]	Nitrogen[4]	Phosphorus[5]	Potassium[6]	Sulfur[7]	Acidifying Action	Alkalizing Action
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	Units[8]	Units[9]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Animal By product								
1	Blood dried	0 4		13 0	0 9	0 8		25	
2	Bone meal raw	22.5	0 6	4 0	9 8		0 2		20
3	Bone meal steamed	25 6	0 3	2 5	10 9		0.2		25
4	Fish scrap or meal dried	6.1	0 3	9 5	3 1		0 2	5	
5	Hoof and horn meal	1 8		14 0	0.4		0 8	+10	
6	Tankage	11 1	0 3	7 0	4 4	0 4	0 4		15
7	Tankage process	0 4		9 0	0 2		0 4	16	
8	Whale guano or tankage	6 4	0 3	9 5	2.8			4	
9	Wool waste	0 4		3 5	0.2	1.7			
	Animal Excreta								
10	Guano bat	5 4	0 3	8 5	2.2	1 2	0 8	+10	
11	Guano Peruvian	7 9	0 6	13 0	5.2	2 1	1.4	13	
12	Manure cattle	2 9	0 6	2.0	0 7	1.7	0.2		+11
13	Manure horse	1.1	0 6	2 0	0.7	1.2	0.2		11
14	Manure poultry	2.9	0 6	5.0	1 5	1 2	0 8	+10	
15	Manure sheep	3 6	1.2	2.0	0 7	2.5	0 6		+11
16	Sewage sludge activated	1.8	0.9	6 0	1 5	0 4	0 4	10	
17	Sewage sludge dried	1 8	0 3	2.0	0 9		0 2	+10	
	Plant Residues								
18	Castor pomace	0 4	0 3	5 5	0.7	1 2		6	
19	Cocoa shell meal	1 1	0.3	2.5	0.4	1.7			2
20	Cottonseed hull ash	6 8	3 0		2 4	22 4	1 0		55
21	Cottonseed meal	0 4	0 5	7 0	1.3	1.7	0 2	10	
22	Garbage tankage	3.2	0 3	2.5	1.5	0 8	0 4		7
23	Kelp Pacifi	1.1	0.6	2.5	0 7	12 5	1.0		
24	Linseed meal	0 4	0 6	5 5	0 9	1.2	0 4		
25	Peat moisture-free	0 7	0.3	2.0			0 2	+12	12
26	Seaweed dried	2.1	0 6	1.5	0 2	1.7	1 4		
27	Soybean meal	0.4	0.3	7 0	0 7	2 1	0 2	+10	
28	Tobacco ash	15 7	3 6		1.3	19 1			+11
29	Tobacco stems	3 6	0 3	2.0	0.2	3 0	0 4		25
30	Wood ash commercial	25 2	2.1		0.9	4 2	0 4		+11

/1/ Data represent the total amount present. /2/ Calcium x 1 3992 calcium oxide CaO. /3/ Magnesium 1 6579 magnesium oxide MgO. /4/ Nitrogen 6 0683 sodium nitrate $NaNO_3$ /5/ Phosphorus 2.2914 phosphorus pent oxide P_2O_5. /6/ Potassium 1 2046 potassium oxide K_2O /7/ Sulfur 2 4969 sulfur trioxide SO_3 /8/ Grams of calcium carbonate $CaCO_3$ required to neutralize the soil acidity resulting from the use of 100 grams of the ferti lizer material. /9/ Grams of calcium carbonate that correspond in acid-neutralizing power to 100 grams of the ferti lizer material. That i a material having an alkalinizing action of 20, .g bone meal indicates that 100 grams of thi material applied to the soil would be equivalent to 20 grams of calcium carbonate for neutralizing soil acidity /10/ The material is acidi /11/ The material is basic /12/ Some peats are acidic others basi

64 SOIL pH REQUIREMENTS: PLANTS

Plant growth is best at the optimum pH (col. B) and only fair at the limits of the range (col. C).

	Species	Soil pH Optimum	Soil pH Range[a]
	(A)	(B)	(C)
	Field and Forage Crops		
1	Alfalfa (Medicago sativa)	6.0-7.5	5.5-8.5
2	Barley (Hordeum vulgare)	6.5-7.5	5.5-8.5
3	Beet, sugar (Beta vulgaris)	6.5-8.0	5.5-8.5
4	Bluegrass, Kentucky (Poa pratensis)	5.5-7.5	
5	Buckwheat (Fagopyrum esculentum)	5.5-7.0	4.5-8.0
6	Clover, red (Trifolium pratense)	6.0-7.5	5.5-
7	Clover, white (T. repens)	5.5-7.0	5.0-
8	Cotton (Gossypium hirsutum)	5.0-6.0	-8.5
9	Flax (Linum usitatissimum)	5.0-7.0	-8.5
10	Hemp (Cannabis sativa)	6.0-7.0	
11	Oats (Avena sativa)	5.0-7.5	4.5-8.0
12	Peanut (Arachis hypogaea)	5.5-6.5	-8.0
13	Redtop (Agrostis alba)	5.0-6.0	7.0
14	Rice (Oryza sativa)	5.0-6.5	7.0
15	Rye (Secale cereale)	5.0-7.0	4.5-8.0
16	Sorghum (Sorghum vulgare)	5.5-7.5	4.5-8.0
17	Soybean (Glycine soja)	6.0-7.0	5.5-
18	Sugar cane (Saccharum officinarum)	6.0-8.0	5.0-
19	Sunflower (Helianthus annuus)	6.0-7.5	
20	Sweetclover (Melilotus alba)	6.5-8.0	
21	Tobacco (Nicotiana tabacum)	5.5-7.5[1]	4.5-
22	Wheat (Triticum aestivum)	5.5-7.5	5.0-8.5
	Fruit and Vegetable Crops		
23	Apple (Pyrus malus)	5.0-7.0	-8.0
24	Bean, lima (Phaseolus lunatus mac.)	6.0-7.0	
25	Bean, snap and wax (P. vulgaris)	6.0-7.5	
26	Beet, garden (Beta vulgaris)	6.0-7.5	5.5-
27	Blueberry (Vaccinium spp.)	4.5-6.0	
28	Cabbage (Brassica oleracea capitata)	6.0-7.5	-8.5
29	Cantaloupe (Cucumis melo)	6.0-8.0	
30	Carrot (Daucus carota)	5.5-7.0	5.0-8.5
31	Celery (Apium graveolens dulce)	6.0-7.0	-8.5
32	Corn (Zea mays)	5.5-7.5	5.0-8.0
33	Cress, garden (Lepidium sativum)	6.0-7.0	
34	Cucumber (Cucumis sativus)	5.5-7.0	-8.0
35	Lemon (Citrus limonia)	6.0-7.5	-8.5
36	Lettuce (Lactuca sativa)	6.0-7.0	5.5-8.0
37	Onion (Allium cepa)	6.0-7.0	5.0-7.5
38	Orange, sweet (Citrus sinensis)	6.0-7.5	-8.0
39	Parsley (Petroselinum hortense)	5.0-7.0	
40	Pea, garden (Pisum sativum)	6.0-8.0	
41	Peach (Prunus persica)	6.0-7.5	-8.0
42	Pear (Pyrus communis)	6.0-7.5	-8.0
43	Pepper (Capsicum annuum)	5.5-7.0	
44	Pineapple (Ananas sativus)	5.0-6.0	7.0
45	Potato (Solanum tuberosum)	5.0-6.5[2]	-8.0
46	Radish (Raphanus sativus)	6.0-7.0	5.0-8.0
47	Spinach (Spinacia oleracea)	6.0-7.5	-8.5
48	Squash, winter (Cucurbita maxima)	5.5-7.0	
49	Strawberry (Fragaria spp.)	5.0-6.5	4.5-8.0
50	Sweetpotato (Ipomoea batatas)	5.0-6.0	7.5
	Fruit and Vegetable Crops (concluded)		
51	Tomato (Lycopersicon esculentum)	5.5-7.5	
52	Turnip (Brassica rapa)	5.5-7.0	
53	Watermelon (Citrullus vulgaris)	5.5-6.5	5.0-8.0
	Ornamental Shrubs and Herbaceous Plants		
54	African violet (Saintpaulia ionantha)	6.0-7.0	
55	Aster, China (Callistephus chinensis)	6.5-7.0	5.5-
56	Balsam, garden (Impatiens balsamina)	6.0-7.5	5.5-
57	Begonia (Begonia spp.)	6.0-7.0	
58	Camellia (Camellia japonica)	4.5-5.5	
59	Canna (Canna indica)	6.0-8.0	
60	Carnation (Dianthus caryophyllus)	6.0-7.5	5.0-
61	Chrysanthemum (Chrysanthemum morifolium)	6.0-7.5	5.0-8.0
62	Coleus (Coleus blumei)	6.0-7.0	
63	Dahlia (Dahlia spp.)	6.0-8.0	
64	Gardenia (Gardenia jasminoides)	5.0-7.0	
65	Geranium (Pelargonium domesticum)	6.0-8.0	5.0-
66	Gladiolus (Gladiolus spp.)	6.0-8.0	
67	Hibiscus, Chinese (Hibiscus rosa-sinensis)	6.0-8.0	
68	Holly, English (Ilex aquifolium)	5.0-7.0	
69	Hyacinth (Hyacinthus orientalis)	6.5-7.5	
70	Iris, bearded (Iris spp.)	6.0-8.0	
71	Ivy, English (Hedera helix)	6.0-8.0	
72	Kalanchoe (Kalanchoe blossfeldiana)	6.0-7.5	
73	Lily, Easter (Lilium longiflorum)	6.0-7.0	
74	Nasturtium (Tropaeolum majus)	5.5-7.5	5.0-
75	Narcissus (Narcissus spp.)	5.0-7.0	
76	Primrose, evening (Oenothera biennis)	6.0-8.0	
77	Rhododendron (Rhododendron obtusum)	4.5-6.0	
78	Rose (Rosa hybrida)	5.5-7.0	5.0-7.5
79	Snapdragon (Antirrhinum majus)	6.0-7.5	5.0-8.0
80	Spiderwort (Tradescantia virginiana)	5.0-7.5	
81	Stock (Matthiola incana)	6.0-7.5	
82	Tulip (Tulipa gesneriana)	6.0-7.0	7.5
	Miscellaneous Trees		
83	Arborvitae (Thuja occidentalis)	6.0-7.5	5.5-8.5
84	Aspen, quaking (Populus tremuloides)	4.0-5.5	
85	Elm (Ulmus spp.)[3]	6.0-8.0	
86	Hemlock (Tsuga canadensis)	5.0-6.0	7.0
87	Holly, American (Ilex opaca)	5.0-6.0	
88	Locust, black (Robinia pseudoacacia)	6.0-7.5	
89	Magnolia (Magnolia grandiflora)	5.0-7.0	
90	Maple, sugar (Acer saccharum)	6.0-7.5	
91	Oak (Quercus spp.)[4]	5.0-6.5	
92	Oak, white (Q. alba)	6.0-7.0	
93	Pine, longleaf (Pinus palustris)	4.5-5.0	-6.0
94	Pine, red (P. resinosa)	5.0-6.0	4.5-
95	Spruce, Sitka (Picea sitchensis)	5.0-6.0	7.0

/1/ For disease control, 6.0. /2/ For scab control, 5.4. /3/ Species include: American elm (U. americana), Chinese elm (U. parvifolia). /4/ Species include: Chestnut oak (Q. montana), pin oak (Q. palustris).

65 PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES FOODSTUFFS OF ANIMAL ORIGIN

Values with the exception of Calories are in grams per 100 grams of edible portion of food stuff, ready for cooking or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number. For mineral and vitamin composition see table 66

	Foodstuff / Constituents	Energy Value[1]	Water	Total Solids[2]	Protein	Fat	Carbo-hydrate	Ash
		Cal/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Dairy Products							
1	Butter	716	15	85	0 6	81	0.4	2 5
2	Buttermilk, cultured	36	90	9	3 5	0.1	5 1	0.8
3	Cheese, cheddar	398	37	63	25	32	2 1	3 7
4	Cheese, cottage	95	76	24	19 5	0 5	2	1 5
5	Cheese cream	371	51	49	9	37	2	1
6	Cheese Swiss	370	39	61	28	28	1 7	3 8
7	Cream, light table or coffee	204	72	28	2 9	20	4	0 6
8	Milk, cow skimmed pasteurized & raw	36	90	10	3 5	0.1	5.1	0 8
9	Milk, cow whole pasteurized & raw	68	87	13	3 5	3 9	4 9	0 7
10	Milk, goat	67	87	13	3 3	4	4 6	0 7
	Fats and Oils							
11	Lard	902	0	100	0	100	0	0
	Meats							
12	Beef brains[3]	125	79	21	10.4	8 6	0 8	1.4
13	Chuck[4]	224	65	35	18 6	16	<0 5	0 9
14	Flank[4]	247	61	39	19 9	18	<0 5	0 9
15	Hamburger[4]	321	55	45	16	28	<0 5	0.8
16	Heart lean	108	78	22	16 9	3 7	0 7	1 1
17	Kidney	141	75	25	15	8.1	0 9	1 1
18	Liver	136	70	30	19 7	3.2	6	1.4
19	Porterhouse[4]	296	58	42	16 4	25	<0 5	0 8
20	Rib roast[4]	282	59	41	17.4	23	<0 5	0 8
21	Round[4]	182	69	31	19 5	11	<0 5	1
22	Rump[4]	322	55	45	16.2	28	<0 5	0 8
23	Stew meat[5]	333	53	47	15 8	30	<0 5	0 7
24	Sweetbreads	344	54	46	11.8	33	<0 5	1 1
25	Tongue	207	68	32	16 4	15	0.4	0 9
26	Lamb chop rib[4]	356	52	48	14 9	32	<0 5	0 8
27	Heart sheep	162	72	28	16 8	9 6	1	1
28	Kidney sheep	105	78	22	16 6	3 3	1	1 5
29	Leg roast	235	64	36	18	17 5	<0 5	0 9
30	Liver	136	71	29	21	3 9	2 9	1.4
31	Shoulder roast[4]	295	58	42	15 6	25	<0 5	0.8
32	Pork, bacon[4]	630	20	80	9.1	65	1.1	4 3
33	Feet	271	57	43	17 0	22	<0 5	0 8
34	Ham, fresh[4]	344	53	47	15.2	31	<0 5	0 8
35	Ham, smoked[4]	389	42	58	16 9	35		5.4

/1/ Kilocalories Digestibility losses reduce total energy from protein fat and carbohydrates by a small amount and loss in the urine of incompletely oxidized nitrogen products further reduces energy available from protein. Energy values have been calculated by using these factors for Calories per gram protein fat and carbohydrate respectively: from milk 4 27 8 79 and 3 87; for meat and fish 4 27, 9 02 and 3 87; from eggs 4 36 9 02 and 3 68 /2/ Values rounded to nearest whole number /3/ Data applicable to all species of edible brains /4/ Medium fat. /5/ Also listed as "Wholesale cuts: plate and brisket medium.

65 PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES FOODSTUFFS OF ANIMAL ORIGIN (Continued)

Values, with the exception of Calories, are in grams per 100 grams of edible portion of food stuff, ready for cooking or ready to eat if consumed uncooked Values of 25 and above have been rounded to the nearest whole number For mineral and vitamin composition see table 66

	Foodstuff \ Constituents	Energy Value[1]	Water	Total Solids[2]	Protein	Fat	Carbo-hydrate	Ash
		Cal/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Meats (concluded)							
36	Heart	117	77	23	16 9	4 8	0.4	1 1
37	Kidney	114	77	23	16 3	4 6	0.8	1.2
38	Liver	134	72	28	19 7	4 8	1 7	1 5
39	Loin or chops, fresh	296	58	42	16 4	25	<0 5	0 9
40	Salt pork	783	8	92	3 9	85	<0 5	3 5
41	Sausage link or bulk	450	42	58	10 8	45	<0 5	2.1
42	Spare ribs canned	351	53	47	14 6	32	<0 5	0 8
43	Tenderloin	148	72	28	19 9	7	<0 5	1.1
44	Tongue	214	66	34	16 8	15.6	0 5	1
45	Rabbit domesticated	135	73	27	21 0	5	0	1.1
46	Veal chops, loin	176	69	31	19.2	11	0	1
47	Cutlet, boned (wholesale round)[4]	164	70	30	19 5	9	<0 5	1
48	Heart	133	76	24	15 4	7.1	0 8	1.2
49	Kidney	119	76	24	16 8	5.2	0.2	1.4
50	Leg roast	186	68	32	19 1	12.2	0	1
51	Liver	141	71	29	19	4 9	4	1 3
52	Stew meat boned[4]	231	64	36	18 3	17	<0 5	0 9
53	Shoulder roast, boned (wholesale chuck)[4]	173	70	30	19 4	10	<0 5	1
54	Venison	140	73	27	20	6	0	1
	Poultry							
55	Chicken, roasters	200	66	34	20.2	12 6	<0 5	1
56	Heart	157	70	30	20 5	7	1 6	1 3
57	Liver	141	70	30	22.1	4	2.6	1 7
58	Duck, domesticated	326	54	46	16	29	<0 5	1
59	Goose, domesticated	354	51	49	16 4	32	<0 5	0 9
60	Turkey[4]	268	58	42	20 1	20.2	<0 5	1
61	Liver	134	71	29	22	4 8	0 7	1.6
	Eggs: Chicken[6]							
62	Egg white	50	88	12	10 8	<0 5	0 8	0 6
63	Egg, whole	162	74	26	12 8	11 5	0 7	1
64	Egg yolk	361	49	51	16 3	32	0 7	1 7
	Fish and Shellfish							
65	Clam	81	80	20	12 8	1.4	3.4	2 1
66	Cod	74	83	17	16 5	0 4	<0 5	1.2
67	Crab, Atlantic & Pacific hard-shell	66	80	20	16 1	1 6	0 6	1.7
68	Flounder	68	83	17	14 9	0 5	<0 5	1 3

/1/ Kilocalories Digestibility losses reduce total energy from protein fat and carbohydrates by a small amount and loss in the urine of incompletely oxidized nitrogen products further reduces energy available from protein Energy values have been calculated by using these factors for Calories per gram protein fat and carbohydrate respectively: from milk, 4 27, 8 79 and 3 87; for meat and fish 4 27 9 02 and 3 87; from eggs, 4 36 9 02 and 3 68 /2/ Values rounded to nearest whole number /4/ Medium fat /6/ Fresh frozen or stored

65 PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES FOODSTUFFS OF ANIMAL ORIGIN (Concluded)

Values with the exception of Calories are in grams per 100 grams of edible portion of foodstuff ready for cooking or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number For mineral and vitamin composition see table 66

	Foodstuff / Constituents	Energy Value[1]	Water	Total Solids[2]	Protein	Fat	Carbohydrate	Ash
		Cal/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Fish and Shellfish (concluded)							
69	Haddock	79	81	19	18.2	0 1	<0 5	1 4
70	Halibut	126	75	25	18 6	5.2	<0 5	1
71	Herring Atlantic	191	67	33	18 3	12 5	<0 5	2 7
72	Herring Pacific	94	80	20	16 6	2 6	<0 5	1 3
73	Lobster	88	79	21	16.2	1 9	0 5	2.2
74	Oyster	84	80	20	9 8	2 1	5.6	2
75	Perch, white	113	76	24	19 3	4	0	1.2
76	Salmon, Pacific (Chinook or King)	225	63	37	17.4	16 5	<0 5	1
77	Scallops muscle	78	80	20	14 8	0.1	3 4	1 4
78	Shrimp fresh (without shell)							
79	Tuna, canned	198	60	40	29	8.2	<0 5	2 7
80	Whitefish, canned	156	70	30	22 9	6 5	0	1.6

/1/ Kilocalories Digestibility losses reduce total energy from protein fat and carbohydrates by a small amount and loss in the urine of incompletely oxidized nitrogen products further reduces energy available from protein. Energy values have been calculated by using these factors for Calories per gram protein, fat and carbohydrate respectively; from milk, 4.27, 8 79 and 3.87; for meat and fish, 4.27, 9 02 and 3 87; from eggs 4 36 9 02 and 3 68 /2/ Values rounded to nearest whole number

66 MINERAL AND VITAMIN COMPOSITION FOODSTUFFS OF ANIMAL ORIGIN

Values are milligrams per 100 grams edible portion of foodstuff ready for cooking, or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number. Imputed values based on inadequate evidence are enclosed in parentheses. For ash content see table 65.

	Foodstuff	Mineral			Vitamins				
		Calcium	Iron	Phosphorus	Vit. A cal. as β-carotene[1]	Ascorbic Acid[2]	Niacin[3]	Riboflavine	Thiamine
		mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	Dairy Product								
1	Butter	20	0	16	1.99[4]	0	0.1	0.01	Trace
2	Buttermilk, cultured	(118)	0.1	93	Trace	1	0.1	0.18	0.04
3	Cheese, cheddar	725[5]	1.0	475[5]	0.84	(0)	Trace	0.42	0.02
4	Cheese, cottage	96[6]	0.3	189[6]	(0.01)	(0)	(0.1)	0.31	0.02
5	Cheese, cream	68[7]	0.2	97[7]	(0.87)	(0)	0.1	0.22	(0.01)
6	Cheese, Swiss	925[8]	0.9	563[8]	0.87	(0)	(0.1)	(0.40)	0.01
7	Cream, light, table or coffee	97	0.1	77	0.5	1	0.1	0.14	0.03
8	Milk, cow, skimmed, pasteurized or raw	123	0.1	97	Trace	1	0.1	0.18	0.04
9	Milk, cow, whole, pasteurized or raw	118	0.1	93	(0.1)	1	0.1	0.17	0.04
10	Milk, goat	129	0.1	106	(0.1)	1	0.3	0.11	0.04
	Fats and Oils								
11	Lard	0	0	0	0	0	0	0	0
	Meat								
12	Beef, brains[9]	16	3.6	330	0	18	4.4	0.26	0.23
13	Chuck	11	2.8	167	(0)	0	4.5	0.17	0.08
14	Flank	12	3.0	186	(0)	0	4.8	0.18	0.09
15	Hamburger	9	2.4	128	(0)	0	3.8	0.14	0.07
16	Heart, lean	9	4.6	203	0.02	6	7.8	0.89	0.58
17	Kidney	9	7.9	221	0.69	13	6.4	2.55	0.37
18	Liver	7	6.6	358	26	31	13.7	3.33	0.26
19	Porterhouse	10	2.5	154	(0)	0	3.9	0.15	0.07
20	Rib roast	10	2.6	149	(0)	0	4.2	0.15	0.07
21	Round	11	2.9	180	(0)	0	4.7	0.17	0.08
22	Rump	9	2.4	151	(0)	0	3.9	0.14	0.07
23	Stew meats	9	2.4	170	0	0	4.3	0.12	0.10
24	Sweetbreads	14	1.6	596					
25	Tongue	9	2.8	187	(0)	(0)	5.0	0.29	0.12
26	Lamb, rib[10]	9	2.2	138	(0)	0	4.3	0.18	0.13
27	Heart, sheep								
28	Kidney, sheep	13	9.2	257	(0.69)	13	7.4	2.42	0.51
29	Leg roast[10]	10	2.7	213	(0)	0	5.2	0.22	0.16
30	Liver	8	12.6	364	30	33	16.9	3.28	0.40
31	Shoulder roast[10]	9	2.3	155	(0)	0	4.5	0.19	0.14
32	Pork, bacon[10]	13	0.8	108	(0)	0	1.9	0.12	0.38
33	Butt[10]	12	3.0	245	(0)	0	5.2	0.24	0.98
34	Ham, fresh[10]	9	2.3	168	(0)	0	4.0	0.18	0.74
35	Ham, smoked[10]	10	2.3	136	(0)	0	4.0	0.19	0.70
36	Heart	35	2.7	132	0.02	6	6.0	1.24	0.43
37	Kidney	11	8.0	246	0.08	13	9.8	1.74	0.38
38	Liver	10	18.0	362	8.52	23	16.7	2.98	0.40
39	Loin or chops, fresh	10	2.3	186	(0)	0	4.3	0.19	0.80
40	Salt pork	Trace	0.6	Trace[11]	(0)	0	(0.9)	(0.04)	(0.18)

/1/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene = 1 I.U. vitamin A. /2/ Ascorbic acid based for most part on determinations of reduced ascorbic acid. /3/ Niacin values were derived from data in the literature for nicotinic acid, nicotinamide and other related compounds. /4/ Year-round average. /5/ Also reported: calcium 875 mg/100g, and phosphorus 610 mg/100g. /6/ Also reported: calcium 82 mg/100g, and phosphorus 263 mg/100g. /7/ Also reported: calcium 298 mg/100g, and phosphorus 208 mg/100g. /8/ Also reported: calcium 1100 mg/100g and phosphorus 811 mg/100g. /9/ Data applicable to all species of edible brains. /10/ Medium fat. /11/ Also reported phosphorus 42 mg/100g.

66 MINERAL AND VITAMIN COMPOSITION FOODSTUFFS OF ANIMAL ORIGIN (Concluded)

Values are milligrams per 100 grams edible portion of foodstuff ready for cooking or ready to eat if consumed uncooked Values of 25 and above have been rounded to the nearest whole number Imputed values based on inadequate evidence are enclosed in parentheses For ash content see table 65.

Foodstuff / Constituents	Minerals: Calcium	Minerals: Iron	Minerals: Phosphorus	Vitamins: Vit. A value as β-carotene[1]	Vitamins: Ascorbic Acid[2]	Vitamins: Niacin[3]	Vitamins: Riboflavin	Vitamins: Thiamine
	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
Meat (concluded)								
Pork (concluded)								
41 Sausage links or bulk	6	1.6	100	(0)	0	2.3	0.17	0.43
42 Spare ribs[10]	8	2.2	158	(0)	0	3.8	0.17	0 71
43 Tenderloin								
44 Tongue	29	1.4	186	(0)	(0)	(5 0)	(0.29)	0.17
45 Rabbit, domesticated	20	1 3	352			12.8	0.06	0 08
46 Veal, chops loin	11	2 9	207	0	0	6 3	0.27	0.18
47 Cutlet, boned	11	2 9	200	(0)	0	6 5	0.26	0.14
48 Heart								
49 Kidney								
50 Leg roast	11	2 9	206	0	0	6.5	0.27	0.17
51 Liver	6	10.6	343	13 5	36	16.1	3.12	0.21
52 Stew meat boned[10]	11	2 7	182	(0)	0	6.1	0.24	0.13
53 Shoulder roast, boned (wholesale chuck)[10]	11	2 9	199	(0)	0	6 5	0.26	0.14
54 Venison								
Poultry								
55 Chicken, roasters	14	1.5	200	0	0	8.0	0.16	0.08
56 Heart	25	1.7	142	0.02	6	5.2	0 91	0.12
57 Liver	16	7.4	240	19 3	20	11.8	2.46	0.20
58 Duck, domesticated	15	1.8	188		(0)	5.6	0.24	0.10
59 Goose domesticated	15	1.8	188		(0)	5.6	0.24	0.10
60 Turkey[10]	23	3.8	320		(0)	8.0	0.14	0.09
61 Liver								
Egg, chicken[12]								
62 Egg white	6	0.2	17	(0)	0	(0.1)	0.26	0
63 Egg whole	54	2 7	219	0.48	0	0.1	0.29	0 10
64 Egg yolk	147	7.2	586	1 93	0	Trace	0 35	0.27
Fish and Shellfish								
65 Clam	(96)	(7.0)	(139)	0.07		(0.1)	0.18	0.10
66 Cod	10	0.4	194	0	2	2.2	0 09	0 06
67 Crab Atlantic and Pacific hard-shell	(39)	(0 8)	(160)			2 7	0 06	0.14
68 Flounder	12	0.8	195			1.7	0 05	0 06
69 Haddock	23	0 7	197			2.4	0 08	0.05
70 Halibut	13	0 7	211	0.26		9.2	0.06	0.07
71 Herring, Atlantic		1.1	256	0 07		3.4	0 15	0.02
72 Herring, Pacific				0 06		(2.2)	0.22	0.02
73 Lobster	61	0.6	184			(1.9)	0 06	(0 13)
74 Oyster	94	5.6	143	0 19		1.2	0.20	0.15
75 Perch, white								
76 Salmon, Pacific (Chinook or King)		(0.9)	(289)	0.19	9	7.2	0.25	0 10
77 Scallops muscle	26	1.8	208	0		1.4	0.10	(0 04)
78 Shrimp fresh without shell	63	1.6	166	(0 04)	(0)	2.2	0.14	0 03
79 Tuna, canned	(8)	1.4	(351)	0.05	(0)	12.8	0 12	0 05
80 Whitefish, canned	150	0.4	263				0 09	

/1/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity 0 0006 mg β-carotene = 1 I U vitamin A. /2/ Ascorbic acid based for most part on determinations of reduced ascorbic acid /3/ Niacin values were derived from data in the literature for nicotinic acid, nicotinamide and other related compounds /10/ Medium fat /12/ Fresh, frozen or stored.

67 CHEMICAL COMPOSITION OF MILK

Values per 100 ml whole milk

Species / Constituent	Man: Colostrum[1] Value	Man: Colostrum[1] Range[4]	Man: Transitional Milk[2] Value	Man: Transitional Milk[2] Range[4]	Man: Mature Milk Value	Man: Mature Milk Range[4]	Cow: Mature Milk Value	Cow: Mature Milk Range[4]	Goat: Mature Milk Value	Goat: Mature Milk Range[4]
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1 Water, g	87	[illegible]	87	[illegible]	88	82–90	87	80–92	87	81–90
2 Calories, kilocalories[3]	[illegible]		63		75		65		68	
3 Total solids, g	12.8	11–17	13	10–16	12.4	10–17	12.7	8–20	13.4	10–19
4 Ash, g	0.33	0.2–0.7	0.24	0.1–0.4	0.21	0.1–0.3	0.72	0.3–1.2	0.77	0.4–1.1
5 Protein, g	2.7	1–11	1	1.3	1.2	1–6	3.3	2–6	3.5	2.5
6 Amino acids, total, g	1.20	0.7–4.0	0.54	0.6–1.0	1.19	0.9–1.6	3.3	2.7–4.1		
7 Casein, g	1.2	0.3–3.2	[illegible]	0.4–1.8	0.4	0.04–0.7	2.8	1.4–6.3	2.5	1.7–3.9
8 Lactalbumin, g			0.8		0.3	0.1–0.6	0.4	0.2–0.6	0.4	0.4–0.6
9 Lactoglobulin, g	3.5	0.4–13	0.5	0.2–1.4	0.2		0.2	0.1–0.4	0.3	
10 Whey protein, g	1.7				0.6	<0.3–1.1	0.6	0.2–1.4	1.1	0.8–2.0
11 Carbohydrate, g	5.3	1.1–7.9	6.6	4.8–6.4	7.0	4.2–9.2	4.8	2.1–6.1	4.7	3.3–6.4
12 Fat, g	2.9	0.7–12.7	3.6	0.4–9.6	3.8	0.5–9.0	3.7	0.9–9.8	4.1	1.2–8.4
13 Essential fatty acid, mg[5]	246				546		99		168	
14 Vitamin A as calculated total[6], mg	0.1	0.02–0.47	0.1	0.06–0.2	0.06	0.01–0.25	0.04	0.015–0.95		
15 Ascorbic acid, mg	4.4	0.4–10.4	5.4	2.7–9.0	4.3	0–11.2	1.8	0.2–3.1	1.4	Trace–3.2
16 Biotin, µg	0.1	Trace–0.3	0.4	Trace–1.8	0.4	Trace–4.2	3.5	0.2–11.0	6.3	4.7–8.3
17 Choline, mg					9	5–14	13	4–28		
18 Cobalamin[7], µg	0.06	0.01–0.15	0.04	0.00–0.07	Trace		0.56	0.07–1.15	0.08	0.00–0.14
19 Vitamin D, cal. as calciferol[8], µg					0.01	0–0.25	0.06	0.01–0.1		
20 Vitamin E, mg	1.3	0.1–4	1.3	0.5–3	0.6	0.1–1	0.1			
21 Folic acid group[9], µg	0.05	0.01–0.15	0.02	0.015–0.025	0.2	0.1–50	0.2	0.1–5	0.03	0.00–0.14
22 Inositol, mg					39	19–56	13	9–39	21	14–24
23 Vitamin K, cal. as K_1[10], µg					2	0–17	8	0–33		
24 Niacin[11], µg	75	10–145	175	60–360	172	66–690	85	19–150	273	200–320
25 Pantothenic acid, µg	183	29–302	288	135–412	196	80–584	350	155–564	289	130–558
26 Para-aminobenzoic acid										
27 Pyridoxine group[12], µg					11	2–22	48	3–95	7	4–13
28 Riboflavine, µg	29.6	12–50	33.2	27–49	42.6	13–100	157	20–342	114	76–690
29 Thiamine, µg	15	0.5–?2	6	0–26	16	<1–43	42	11–90	48	32–68
30 Calcium, mg	31	13–66	34	18–63	33	15–61	125	58–?41	130	103–176
31 Chlorine, mg	91	20–233	54	17–136	43	9–555	103	70–290	159	56–260
32 Cobalt, µg							0.06			
33 Copper, mg	0.05	0.02–0.6	0.05	0.04–0.07	0.04	0.01–0.07	0.03	0.003–0.40	0.04	0.02–0.05[13]
34 Fluorine, µg							16	7–28		
35 Iodine, µg	12	4.5–45	2		7	4–9	21	0.4–187		
36 Iron, mg	0.09	0.08–0.13	0.04	0.02–0.05	0.15	0.02–0.45	0.10	0.01–1.0	0.05	0.01–0.07
37 Magnesium, mg	4	1–8	4	2–5	4	2–6	13	7–22	16	10–24
38 Manganese, µg	Trace				0.7		2	<1–4	8	7–9
39 Phosphorus, mg	14	4–25	17	10–32	15	7–35	99	56–129	106	84–161
40 Potassium, mg	74	66–87	64	53–77	55	27–81	138	38–287	181	106–242
41 Silicon							Trace			
42 Sodium, mg	48	26–136	29	19–54	15	2–44	58	31–214	41	19–60
43 Sulfur, mg	22	20–26	20	15–23	14	5–30	30	24–44	16	–29
44 Zinc, mg	0.62	0.07–0.98	0.77	0.04–>1.15	0.53	0.08–>1.58	0.38	0.17–0.66	Trace	

/1/ 1st–5th day of lactation. /2/ 6th–10th day of lactation. /3/ Kilocalories calculated on basis of "physiological fuel values" of 8.80 calories per gram of fat; 3.85 calories per gram of carbohydrate (lactose); and 4.25 calories per gram of protein. /4/ Represents only the total of values that are available. Determinations of some individual amino acids have not been reported for certain types of milk. /5/ Arachidonic octadecadienoic acid. /6/ Milligrams of carotenoids 0.75 (0.6 x 4.5) plus mg preformed vitamin A = estimated total vitamin A. /7/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /8/ 0.025 µg calciferol = one I. U. /9/ Folic acid is not a chemical entity but a general term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /10/ 0.083 µg vitamin K_1 = one Dam unit. /11/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, antiblacktongue factor. /12/ Includes pyridoxine, pyridoxal, pyridoxamine. /13/ Range of means.

68 PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES FOODSTUFFS OF PLANT ORIGIN

(For minerals see page 116ff for vitamins page 122ff)

Values are with the exception of Calories, grams per 100 grams of edible portion of fresh uncooked foodstuff unless otherwise specified Ranges represent estimate d (cf Introduction) of the 95% range

	Foodstuff / Constituents	Energy Value[1]	Water[2]		Protein		Fat		Total Carbohydrate		Crude Fiber	Ash
		Cal/100g	g/100g		g/100g		g/100g		g/100g		g/100g	g/100g
			Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]		
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
1	Almond, dried (Amygdalus communis)	597	4 7		18 6	13 0–21 0	54 1		19 6		2 7	3 0
2	Apple (Pyrus malus)	58	84	79–91	0 3		0 4	0 3–0 5	14 9		1 0	0 3
3	Apricot (Prunus armeniaca)	51	85	82 92	1 0	0 6–1 1	0 1		12 9	12 3–13 4	0 6	0 6
4	Asparagus (Asparagus officinalis)	21	93		2 2	2 1–3 4	0 2		3 9	3 2–4 5	0 7	0 7
5	Avocado (Persea gratissima)	245	65	55–84	1.7	1 1–2 1	26 4		5 1	3 3–7 4	1 8	1 4
6	Banana (Musa paradisiaca sapientum)	88	75		1 2	1 1–1 3	0 2		23		0 6	0 8
7	Barley pearled dry (Hordeum vulgare)	349	11 1		8 2	7 7–12 4	1 0		78 8		0 5	0 9
8	Bean lima immature (Phaseolus lunatus macrocarpus)	128	67		7 5		0 8		23 5		1 5	1 7
9	Bean lima mature dried (P lunatus macrocarpus)	333	12 6		20 7		1 3		61 6		4 3	3 8
10	Bean red kidney mature dried (P vulgaris)	336	12 2		23 1		1 7		59 4		3 5	3 6
11	Bean snap green and yellow (P vulgaris)	35	89		2 4		0 2		7 7	6 3–14 6	1 4	0 8
12	Beet garden (Beta vulgaris)	42	88		1 6		0 1		9 6		0 9	1 1
13	Beet greens (B vulgaris)	27	90		2 0		0 3		5 6		1 4	1 7
14	Blackberry (Rubus spp)	57	85		1 2		1 0		12 5		4 2	0 5
15	Blueberry (Vaccinium corymbosum)	61	83		0 6		0 6		15 1		1 2	0 3
16	Brazil nut (Bertholletia excelsa)	646	5 3		14.4	13 8–17 0	65 9	61 5–69 4	11 0		2 1	3 4
17	Broccoli (Brassica oleracea botrytis)	29	90		3 3		0 2		5 5		1 3	1 1
18	Brussels sprouts (B oleracea gemmifera)	47	85		4 4		0 5		8 9		1 3	1 3
19	Cabbage (B. oleracea capitata)	24	92	88–94	1 4	1 3–2 7	0 2	0 1–0 3	5 3	4 3–8 7	1 0	0 8
20	Cantaloupe (Cucumis melo cantalupensis)	20	94		0 6		0 2		4 6	4.0–9 3	0 6	0 6
21	Carrot (Daucus carota)	42	88	83–91	1 2		0 3		9 3		1 1	1 0
22	Cashew nut roasted (Anacardium occidentale)	578	3 6		18 5		48 2		27 0	25–29	1 3	2 7
23	Cauliflower (Brassica oleracea botrytis)	25	92		2 4		0 2	0 1–0 5	4 9	4 0–6 3	0 9	0 8
24	Celery (Apium graveolens)	18	94	90–95	1 3		0 2		3 7		0 7	1 1
25	Chard leaves and stems (Beta vulgaris)	21	92		1 4		0 2		4.4		0 9	2 2

26	Cherry sour and sweet (Prunus spp)	61	83	75–85	1 1	0 6–1 3	0 5		14 8	11 9–16 7	0 3	0 6
27	Coconut (Cocos nucifera)	359	47		3 4		4 7		14 0		3 2	1 0
28	Collard (Brassica acephala)	40	87		3 9		0 6		7 2		1 2	1 7
29	Corn sweet white and yellow (Zea mays)	92	74	69–75	3 7		1 2		20 5	19 2 21 0	0 9	0 7
30	Cranberry (Vaccinium macrocarpon)	48	87		0 4		0 7		11 3		1 4	0 2
31	Cress water (Radicula nasturtium aquaticum)	18	94	91–97	1 7		0 3		3 3		0 5	1 1
32	Cucumber (Cucumis sativus)	12	96	95–97	0 7	0 6–0 8	0 1		2 7		0 5	0 4
33	Currant red (Ribes rubrum)	55	84		1 2	0 7–1 6	0 2		13 6		4 0	0 6
34	Dandelion greens (Taraxacum officinale)	44	86	81 88	2 7		0 7		8 8	7 0–10 6	1 8	2 0
35	Date dried (Phoenix dactylifera)	284	20		2 2		0 6		73 4	63 7–73 4	2 4	1 8
36	Eggplant (Solanum melongena)	24	93		1 1	0 7–1 2	0 2		5 5		0 9	0 5
37	Endive (Cichorium endivia)	20	93	91 96	1 6		0 2		4 0		0 9	0 9
38	Fig dried (Ficus carica)	270	24		4 0		1 2		69 4		5 3	2 4
39	Fig fresh (F carica)	79	78	50–85	1 4		0 4		17 6		1 7	0 6
40	Gooseberry (Ribes hirtellum)	39	89		0 8		0 2		9 7	7 6–16 2	1 9	0 4
41	Grape (Vitis spp)[3,4]	70	82		1 4		1 4		14 9	14 4–15 5	0 5	0 4
42	Grapefruit (Citrus grandis)	40	89	86–91	0 5		0 2		10 1		0 3	0 4
43	Guava (Psidium guajava)	70	81		1 0		0 6		17 1		5 5	0 7
44	Honeydew melon (Citrullus sp)	32	91		0 5		0		8 5		0 4	0 5
45	Kale (Brassica oleracea acephala)	40	87		3 9		0 6		7 2	6 0–9 8	.	1 7
46	Lemon (Citrus limonia)	32	89		0 9	0 8–1 0	0 6		8 7		0 9	0 5
47	Lettuce headed (Lactuca sativa)	15	95	91 97	1 2		0 2		2 9		0 6	0 9
48	Lime (Citrus aurantifolia)	37	86		0 8		0 1		12 3		0 5[5]	0 8
49	Mango (Mangifera indica)	66	81		0 7		0 2		17 2		1 0	0 5
50	Mushroom (Agaricus campestris)	16	91		2 4	1 8 3 5	0 3		4 0		0 9	1 1
51	Mustard greens (Brassica japonica)	22	92	87–96	2 3		0 3		4 0		0 8	1 2

/1/ Kilocalories Values were calculated by using specific physiological energy factors as outlined in U S Dep Agr Table of food composition for the armed forces /2/ Values of 25 and above were rounded to nearest whole number /3/ Data applicable to American type /4/ European type; energy value, 66; water 82; protein 0 5; fat 0 4; total carbohydrate 6 7; crude fiber 0 5; ash 0 5 /5/ Based on inadequate evidence

68 PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF PLANT ORIGIN (Continued)

(For minerals see page 116ff, for vitamins page 122ff)

Values are, with the exception of Calories, grams per 100 grams of edible portion of fresh, uncooked foodstuff unless otherwise specified Ranges represent estimate d (of Introduction) of the 95% range

	Foodstuff / Constituents	Energy Value[1]	Water[2]		Protein		Fat		Total Carbohydrate		Crude Fiber	Ash
		Cal/100g	g/100g		g/100g		g/100g		g/100g		g/100g	g/100g
			Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]		
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
52	Oats rolled (Avena sativa)	390	8 3		14 2		7 4		68 2		1 2	1 9
53	Okra (Hibiscus esculentus)	32	90		1 8		0 2		7 4		1 0	0 8
54	Onion immature green (Allium cepa)	45	88		1 0		0 2		10 6		1 8	0 6
55	Onion mature (A. cepa)	45	88		1 4		0 2		10 3		0 8	0 6
56	Orange (Citrus spp)	45	87	83-90	0 9		0 2		11 2	8 5-11 6	0 6	0 5
57	Parsley (Petroselinum hortense)	50	84	79-88	3 7		1 0		9 0		1 8	2 4
58	Parsnip (Pastinaca sativa)	78	79		1 5		0 5		18 2		2 2	1 2
59	Pea garden immature (Pisum sativum)	98	74	70-79	6 7		0 4		17 7		2 2	0 9
60	Pea garden mature, dried (P sativum)	339	11 6		23 8	21 5-24 6	1 4		60 2	50-62	5 4	3 0
61	Peach (Prunus persica)	46	87	82-90	0 5		0 1		12 0		0 6	0 5
62	Peanut roasted (Arachis hypogaea)	559	2 6		26 9	25 8-28 1	44.2	38 6-49 0	23 6	21 2-24 4	2 4	2.7
63	Pear (Pyrus communis)	63	83	76-86	0 7		0 4		15 8		1 4	0 4
64	Pecan (Carya illinoensis)	696	3 0		9 4		73 0		13 0	10 8-15 3	2 2	1 6
65	Pepper green (Capsicum annuum)	25	92	91-94	1 2		0 2	0.1-0 3	5 7		1 4	0 5
66	Persimmon (Diospyros kaki)	78	78		0 8		0 4		20 0		1 9	0 6
67	Pineapple (Ananas sativus)	52	85	81-90	0 4	0 3-0 5	0 2		13 7		0 4	0 4
68	Plum (Prunus spp)	50	86	74-91	0 7		0 2		12 9		0 5	0 5
69	Potato (Solanum tuberosum)	83	78		2 0		0 1		19 1	18 7-20 8	0 4	1 0
70	Prunes dried (Prunus spp)	268	24		2 3		0 6		71 0		1 6	2 1
71	Pumpkin (Cucurbita pepo)	31	91		1.2		0 2	0 1-2 1	7 3		1 3	0 8
72	Radish (Raphanus sativus)	20	94	87-96	1 2	1 0-1 3	0 1		4.2		0 7	1 0
73	Raisins (Vitis vinifera)	268	24		2 3	1 1-2 6	0 5		71 2	64-76	0 6-1 7 6	2 0
74	Raspberry black (Rubus occidentalis)	74	81		1 5		1 6		15 7		6 8	0 6
75	Raspberry red (R. strigosus)	57	84		1 2		0 4		13 8	11 6-14 4	4 7	0 5
76	Rhubarb stems only (Rheum rhaponticum)	16	95		0 5		0 1		3 8		0 7	0 7
77	Rice brown (Oryza sativa)	360	12 0		7 5	6 7-8 0	1 7		77 7	76-80	0 6	1 1

78	Rice white (Oryza sativa)	362	12 3		7 6	5 9–8 0	0 3		79 4		0 2	0 4
79	Rutabaga (Brassica campestris)	38	89		1 1		0 1		8.9		1 3	0 8
80	Rye whole grain (Secale cereale)	321	11		12 1		1 7		73 4		2 0	1 8
81	Soybeans mature, dried (Glycine soja)	331	7 5		34 9		18 1		34.8		5 0	4.7
82	Soybean sprouts (G soja)	46	86		6 2		1 4		5 3		0 8	0 8
83	Spinach (Spinacia oleracea)	20	93		2 3		0 3		3 2		0 6	1.5
84	Squash summer (Cucurbita pepo)	16	95		0 6		0 1		3 9		0 5	0 4
85	Squash winter (C maxima)	38	89		1 5		0 3		8 8		1 4	0 8
86	Strawberry (Fragaria spp)	37	90		0 8	0 6–1 8	0 5		8 3		1 4	0 5
87	Sweetpotato (Ipomoea batatas)	123	69		1 8	1 4–2 1	0 7		27 9		1 0	1 1
88	Tangerine (Citrus reticulata)	44	87		0 8		0 3		10 9		1 0	0 7
89	Tomato (Lycopersicon esculentum)	20	94	93–95	1 0		0 3		4.0		0 6	0 6
90	Turnip (Brassica rapa)	32	91	86–96	1 1		0 2		7 1		1.1	0 7
91	Turnip greens (B. rapa)	30	90		2 9	2 7–4 2	0 4		5 4	4.3–6.3	1 2	1 8
92	Walnut black (Juglans nigra)	672	2 7		18 3	12 5–28	58		18 7		1 9	2 1
93	Walnut English (J regia)	654	3 3		15 0	12 5–18 4	64		15 6		2 1	1 7
94	Watermelon (Citrullus vulgaris)	28	92	91–93	0 5		0 2		6 9		0 6	0 3
95	Wheat, hard red winter whole grain (Triticum vulgare)	330	12 5		12 3		1 8		71 7		2 3	1 7

/1/ Kilocalories Values were calculated by using specific physiological energy factors, as outlined in U S Dept. Agr Table of food composition for the armed forces /2/ Values of 25 and above were rounded to nearest whole number /6/ Estimate d of the 95% range

69 MINERAL COMPOSITION FOODSTUFFS OF PLANT ORIGIN

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses Ranges represent estimate d (cf Introduction) of the 95% range

	Foodstuff \ Minerals	Calcium		Chlorine	Cobalt	Copper
		mg/100g		mg/100g	mg/100g	mg/100g
		Value	Range[d]			
	(A)	(B)	(C)	(D)	(E)	(F)
1	Almond dried (Amydalus communis)	254		2		0 14
2	Apple (Pyrus malus)	6	4–10	4–5		0 08–0 14
3	Apricot (Prunus armeniaca)	16	10–17	2	0 003	0 11–0 18
4	Asparagus (Asparagus officinalis)	21		36–39		0 14
5	Avocado (Persea gratissima)	10		6–16		0 21–0 7
6	Banana (Musa paradisiaca sapientum)	8	7–10	78–125		0 16–0 21
7	Barley, pearled, dry (Hordeum vulgare)	16		105		0 11–0 40
8	Bean, lima, immature (Phaseolus lunatus macrocarpus)	63		9		0 86
9	Bean lima mature, dried (P lunatus macrocarpus	68		32–41		0 65–0 69
10	Bean red kidney (P vulgaris)	163				
11	Bean snap, green and yellow (P vulgaris)	65		24	0 01	
12	Beet, garden (Beta vulgaris)	27	24–30	58–61	0 005–0 009	0 19
13	Beet greens (B vulgaris)	118[1]			0 04	0 09
14	Blackberry (Rubus spp)	32	17–63	10–22		0 11–0 16
15	Blueberry (Vaccinium corymbosum)	16		8		0 11
16	Brazil nut (Bertholletia excelsa)	186		61		1 09–1 39
17	Broccoli (Brassica oleracea botrytis)	130				
18	Brussels sprouts (B oleracea gemmifera)	34		40		0 10
19	Cabbage (B oleracea capitata)	46	45–50	24–39	0 007–0 024	0 05–0 06
20	Cantaloupe (Cucumis melo cantalupensis)	17	16–20	41–44		0 04–0 06
21	Carrot (Daucus carota)	39		36–67	0 002	0 07–0 08
22	Cashew nut, roasted (Anacardium occidentale)	46				
23	Cauliflower (Brassica oleracea botry)	22		30–50		0 14
24	Celery (Apium graveolens)	50		156–183		0 01
25	Chard leaves and stems (Beta vulgaris)	105[1]				
26	Cherry, sour and sweet (Prunus spp)	18	16–20	<1.0	0 0005[2]	0 07–0 14
27	Coconut (Cocos nucifera)	21	13–24	114–120		0 32–0 70
28	Collard (Brassica oleracea acephala)	249				
29	Corn sweet white and yellow (Zea mays)	9	6–10	14	0 0002	0 06–0 08
30	Cranberry (Vaccinium macrocarpon)	14	12–20	5–9		0 09–0 14
31	Cress water (Radicula nasturtium aquaticum)	195	157–240	61–156		0.04–0.14

/1/ Calcium may not be available because of presence of oxalic acid /2/ Applicable to sweet cherry

69 MINERAL COMPOSITION FOODSTUFFS OF PLANT ORIGIN (Continued)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff unless otherwise specified Values based on inadequate evidence are enclosed in parentheses Ranges represent estimate "d" (cf Introduction) of the 95% range

Iodine	Iron		Magnesium	Manganese	Phosphorus		Potassium	Sodium	Sulfur	Zinc
mg/100g	mg/100g		mg/100g	mg/100g	mg/100g		mg/100g	mg/100g	mg/100g	mg/100g
	Value	Range[d]			Value	Range[d]				
(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
	4 4		257	1 94	475		690-856	3 0-5 8	145	
	0 3		5-6	0.03-0.07	10	7-12	90-116	0 2	2 9-3 7	0.04-0.16
	0 5	0 3-0 6	9-12		23	21-30	320-440	0 6-1 0	6 1	0 04
0 011	0 9	0 8-1 0	10	0 10	62		240	2 0		0 32
	0 6	0 5-1 4	29-41	4 21	38	31-50	340-396	3 0	19 4-37	
0 02	0.6	0 4-1 8	31-42	0.64-0.82	28		348-420	0 5-1 2	13 0	0 28
0 007	(2 0)		20	1.51-1.59	189		123	2 6	107	
	2 3	2 2-2 4			158		680	1 0		
	7 5			1.64-2.54	381		1300	1 0		
	6 9				437					
	1 1				44					
	1 0	0 8-2 4	23	0.54-1.35	43		350	110	17	0 93
	3 2	3 1-3 6	1138	1 26	45	40-90	570	130		0 02
	0 9	0 8-1 0	24 30	0 59	32	19-34	150-208	0 2	9.0-12.5	
	0 8	0 2-0 9	10	2.29-4.44	13	10-20	89	0 6	11	
	3 4	2 8-4 0	225-412	0.32-0.92	693		670-760	1 0-1 5	198-293	
	1 3				76					
	1 3	1 2-2 2	10 6	0 27	78		450	11 0	78	
	0 5	0 4-1 2		0.07-0.12	31	26-64	230	5 0	64-71	0 16
0 002	0 4	0 2-0 8		0 04	16	15-30	230	12	1 7	0 09
	0 8	0 4-1 0	12-17	0.06-0.25	37	21-50	224	95	6 9-17	0 11
	5 0				428		560	14		
	1 1	0 9-1.4	6 6	0 17	72		400	24	29	0 23
0 012	0 5		3-10	0 16	40	29-48	278-300	111-137	14 9	
	2 5				36					
0 33[2]	0 4		8 4[2]		20	17-31	239[2]	2 4[2]	5 9[2]	0 15[2]
	2 0	1 8-2 7	39-52	1.31	98		320	16 5-29	44-46	
	1 6				58					
0 002-0 007	0 5		38	0 15	120		240-370	0 4	32	
0 0003	0 6	0 4-1 1	8	0 30	11		65-119	1 0-1 8	7-11.3	
	2.0		17	0.54	46	10-52	314	60	127	0.56

/2/ Applicable to sweet cherry

69 MINERAL COMPOSITION FOODSTUFFS OF PLANT ORIGIN (Continued)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified Values based on inadequate evidence are enclosed in parentheses Ranges represent estimate d (cf Introduction) of the 95% range

	Foodstuff / Minerals	Calcium		Chlorine	Cobalt	Copper
		mg/100g		mg/100g	mg/100g	mg/100g
		Value	Range[d]			
	(A)	(B)	(C)	(D)	(E)	(F)
32	Cucumber (Cucumis sativus)	10	6–23	24–30		0 06–0 11
33	Currant red (Ribes rubrum)	36		14		0 11–0 12
34	Dandelion greens (Taraxacum officinale)	187	63–240	99		0 15
35	Date (Phoenix dactylifera)	72		228–290		0 21–0 38
36	Eggplant (Solanum melongena)	15		24–61		0 07–0 10
37	Endive (Cichorium endivia)	79	44–104	70–167		0 09–0 11
38	Fig dried (Ficus carica)	186				
39	Fig, fresh (F carica)	54		14–18	0 02	0 06–0 07
40	Gooseberry (Ribes hirtellum)	22		6–7		0 08–0 14
41	Grape (Vitis spp)[4]	17	15–20			
42	Grapefruit (Citrus grandis)	22		1–5		0 02–0 06
43	Guava (Psidium guajava)	30				0 02
44	Honeydew melon (Citrullus sp)	(17)				
45	Kale (Brassica oleracea acephala)	225	181–310	122		0 09
46	Lemon (Citrus limonia)	40		2–5		0 26–0 4
47	Lettuce, headed (Lactuca sativa)	22	17–43	39–74	0 005–0 023	0 04–0 15
48	Lime (Citrus aurantifolia)	(40)	15–55	39		0 97
49	Mango (Mangifera indica)	9	5–21	19		0 01
50	Mushroom (Agaricus campestris)	9		21		1 79
51	Mustard greens (Brassica japonica)	220				
52	Oats rolled (Avena sativa)	53		73	Trace	0 23
53	Okra (Hibiscus esculentus)	82				0 12–0 20
54	Onion, immature, green (Allium cepa)	135				
55	Onion mature (A cepa)	32			0 013	
56	Orange (Citrus spp)	33	24–50	3–6		0 07–0 31
57	Parsley (Petroselinum hortense)	193[1]	190–325	156		0 21–0 53
58	Parsnip (Pastinaca sativa)	57	55–60	30–41		0 10–0 12
59	Pea garden, immature (Pisum sativum)	22	15–30	24–38	0 003	0 23–0 24
60	Pea garden, mature, dried (P sativum)	57		35–60		1 4
61	Peach (Prunus persica)	8		4–5		0 01–0 09
62	Peanut roasted (Arachis hypogaea)	74		41–56		0 27–0 96
63	Pear (Pyrus communis)	13	8–20	4–11	0 018	0 10–0 21
64	Pecan (Carya illinoensis)	74		50		1 36
65	Pepper green (Capsicum annuum)	11	6–14	13–19		0 10
66	Persimmon (Diospyros kaki)	6		2		0 41

/1/ Calcium may not be available because of presence of oxalic acid /4/ Applicable to American and European types

69 MINERAL COMPOSITION FOODSTUFFS OF PLANT ORIGIN (Continued)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses Ranges represent estimate "d" (cf Introduction) of the 95% range

Iodine mg/100g (G)	Iron mg/100g Value (H)	Iron mg/100g Range[d] (I)	Magnesium mg/100g (J)	Manganese mg/100g (K)	Phosphorus mg/100g Value (L)	Phosphorus mg/100g Range[d] (M)	Potassium mg/100g (N)	Sodium mg/100g (O)	Sulfur mg/100g (P)	Zinc mg/100g (Q)
	0 33		9	0 15	21	18-33	141-230	13	11	0 16
	0 9	0 6-1 2	13		33	18-50	160-275	2 0-2 3	29	0 20
	3 1	3 0-6 0		0 30	70		430	76		0 97
0 001	2 1	1 6-5 1	59-65	0 15	60	49-64	754-790	4 8	51	0 34
	0 4		10-15	0 11	37		190-238	0 9-2 5	9 0-9 2	
	1 7	1 2-2 8	10-13	0 22	56	38-67	381-400	10 1-18	26-32	
	3 0				111					
	0 6	0 4-0 9	20		32		190-268	1 6-2 0	12 9	0.12-0 36
0 002	0 5		7	0 04	28		210	0 7-1 9	15 9	
0 007	0 6		4	0.08-0.09	21	16-35	316	1 7-3 0	7 4	0.02-0.20
0 001	0 2		10	0 01	18	16-20	200-234	0 5-1 4	5 1-5 3	
	0 7	0 3-1 5			29	16-30				
	(0 4)				(16)					
	2 2	0 4-2 5	37	0.50-0.59	62	60-72	410	110	115	
0 07	0 6		12	0 04	22	11-30	163-360	6-9	8-12 3	0 17
0 004	0 5	0 4-0 7	10-11	0.5-1.08	25	20-42	140-208	3 1-12	11 8-12	0.18-0.47
	(0 6)				(22)					
	0 2		160		13		16			1 91
	1 0	0 7-3 1	13	0 08	115	98-136	467-520	5 0-9 1	34	0 28
0 002	2 9		27		38		450	48		
	4 5		113		405		368	33	155	
	0 7	0 6-2 0	5	0 62	62		220	1 0	14	
	0 9				24					
	0 5				44					
	0 4	0 3-0 8	10-13	0 03	23		170-197	2 9	9 0-9 2	0 17
	4 3		52	0 94	84	80-128	880-1080	28-33		
	0 7	0 5-1 1	22-29	0.03-0.34	80		342	16 5	16 5-26	
	1 9	1 7-2 1	30	0 41	122	104-130	342-370	0 5-1 0	50	
	4 7		116	2 77	388	303-411	985	38	129	
	0 6		8-11	0 11	22	18-24	160-259	0 5	5 6-7 0	0 02
	1 9		181	1 57	393	339-400	680-740	2 0-5 6	377	
	0 3	0 2-0 5	9	0 06	16	10-30	100-129	2 0-2 3	3 4-5 6	0 16
	2 4		152	3 48	324		420	0.3	5 6	
	0 4		45	0 14	25	23-30	170	0 6		
	0 3		9		26		310	0 6	5 0	

/3/ Applicable to pared cucumber; unpared contains 1 2 mg

69 MINERAL COMPOSITION FOODSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified Values based on inadequate evidence are enclosed in parentheses Ranges represent estimate d[d] (cf Introduction) of the 95% range

	Foodstuff / Minerals	Calcium mg/100g Value	Calcium mg/100g Range[d]	Chlorine mg/100g	Cobalt mg/100g	Copper mg/100g
	(A)	(B)	(C)	(D)	(E)	(F)
67	Pineapple (Ananas sativus)	16	8-20	29-50		0 07-0 08
68	Plum (Prunus spp)	17	14-20	2		0 09-0 15
69	Potato (Solanum tuberosum)	11	8-14	38-79	0 006	0 14-0 17
70	Prunes (Prunus spp)	54				
71	Pumpkin (Cucurbita pepo)	21	20-39	10-36		0 03-0 20
72	Radish (Raphanus sativus)	37	20-44	19-54		0 13-0 16
73	Raisins (Vitis venifera)	78		82		0 20-0 27
74	Raspberry, black (Rubus occidentalis)	40				
75	Raspberry, red (R. strigosus)	40	24-50	22		0 13-0 21
76	Rhubarb stems only (Rheum rhaponticum)	51[1]				
77	Rice brown (Oryza sativa)	39		23		0 36
78	Rice, white (O sativa)	24		27-54	0 0006	0 06-0 19
79	Rutabaga (Brassica campestris)	55		58		0 15
80	Rye whole grain (Secale cereale)	(38)	31-55	25-40		
81	Soybean, mature, dried (Glycine soja)	227				
82	Soybean sprouts (G soja)	48				
83	Spinach (Spinacia oleracea)	81[1]		65-74	0 001-0 12	0 12
84	Squash summer (Cucurbita pepo)	15				0 08
85	Squash winter (C maxima)	19				0 04
86	Strawberry (Fragaria spp)	28	22-41	6-18		0 13-0 20
87	Sweetpotato (Ipomoea batatas)	30		85-94	0 002	0 15
88	Tangerine (Citrus reticulata)	(33)		2		0 09-0 11
89	Tomato (Lycopersicon esculentum)	11	7-13	34-51	0 009	0 06-0 11
90	Turnip (Brassica rapa)	40		41-70		0 07-0 09
91	Turnip greens (B rapa)	259	216-374	168	0 003-0 107	0 09
92	Walnut black (Juglans nigra)					
93	Walnut, English (J regia)	83	60-90	30-40	0 005	0 31-1 0
94	Watermelon (Citrullus vulgaris)	7		8		0 07
95	Wheat, hard red winter whole grain (Triticum vulgare)	46				

/1/ Calcium may not be available because of presence of oxalic acid

69 MINERAL COMPOSITION FOODSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified Values based on inadequate evidence are enclosed in parentheses Ranges represent estimate "d" (cf Introduction) of the 95% range

Iodine	Iron		Magnesium	Manganese	Phosphorus		Potassium	Sodium	Sulfur	Zinc
mg/100g	mg/100g		mg/100g	mg/100g	mg/100g		mg/100g	mg/100g	mg/100g	mg/100g
	Value	Range[d]			Value	Range[d]				
(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
	0 3		11-17	1 07	11	8-30	210-247	0 3	2 5-2 6	0 26
0 005	0 5	0 3-0 8	8-11	0 07	20	14-32	170-195	0 6	4 6-6 4	0 03
0 004-0 009	0 7		24-27	0 10	56	40-60	410-568	0 8	34-35	0 02-0 4
	3 9				85					
	0 8	0 4-1 1	8-12	0 04	44	19-60	309-480	0 6-1 3	9 5-13	
	1 0	0 8-1 9	11-15	0 05	31		240-260	9 0	37	0 16
0 003	3 3		42	0.32	129	33-132	860	52	23	
	0 9				37					
	0 9		22	0 51	37	27-52	130-224	0 5	17 3	
	0 5				25					
0 003	2 0		119	1 70	303	290-340	150	9 0		0 3-0 9
0 003	0 8	0 5-1 1	13-28	1 08	136		113	6 3	79	1 5
	0 4			0 13	41		260	5 0		0 30
	3 7	2 7-3 9	92-155		376	352-385	412		134-146	
	8 0				586					
	1 0				67					
	3 0	2 6-4 0	55	0 70	55	40-70	780	82	27	0 62
	0 4		11	0 14	15		150-200	0 2-0 6		
	0 6		8	0 16	28		240	0 3		0 21
	0 8	0 7-0 9	12	0 06	27	23-30	161-180	0 8-1 5	13 4	0 09
	0 7		12	0 15-0 52	49	45-52	530	4 0	14 9	0 23
	(0 4)	0 3-0 6	11	0 04	(23)		110-154	2 2	10 3	0 08
0 001-0 003	0 6		11	0.14	27	21-30	230-288	2 8-3 0	10.6-10 7	0 24
	0 5	0 4-0 7	7	0 04	34	28-50	230-238	37-58	22 1	0 08
	2 4			1 42	50	49-75	440	10	54	0 21
	6 0			3 21			460	3 0		
	2 1		131-134	1 80	380	358-510	450-687	2 0-2 7	104-106	
	0 2		10	0.02-0.18	12	3-13	110	0 30	9 0	
	3 4				354					

70 VITAMIN COMPOSITION FOODSTUFFS OF PLANT ORIGIN

Values are milligrams per 100 grams of edible portion of fresh uncooked foodstuff unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "c" (cf Introduction) of the 95% range.

	Foodstuff	Vitamin A as β-carotene[1] mg/100g Value	Range[d]	Ascorbic Acid mg/100g Value	Range[d]	Niacin mg/100g Value	Range[d]	Riboflavin mg/100g Value	Range[d]	Thiamine mg/100g Value	Range[d]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Almond, dried (Amygdalus communis)	0		Trace		4.6		0.67		0.25	0.12–0.30
2	Apple (Pyrus malus)	0.05	0.02–0.07	5	2–20	0.2	0.1–0.5	0.03	0.01–0.05	0.04	0.01–0.06
3	Apricot (Prunus armeniaca)	1.67		7	1–11	0.8		0.05	0.04–0.11	0.03	0.02–0.05
4	Asparagus (Asparagus officinalis)	0.60	0.18–0.84	33	15–54	1.4		0.19	0.10–0.32	0.16	0.14–0.22
5	Avocado (Persea gratissima)	0.17	0.06–0.33	16	2–28	1.1		0.13	0.09–0.18	0.06	
6	Banana (Musa paradisiaca sapientum)	0.26		10	7–28	0.7		0.05	0.03–0.09	0.04	0.3–0.15
7	Barley, pearled, dry (Hordeum vulgare)	(0)		0		3.1		0.08		0.12	
8	Bean, lima, immature (Phaseolus lunatus macrocarpus)	0.17		32	15–42	1.4		0.11		0.21	
9	Bean, lima, mature, dried (P. lunatus macrocarpus)	0		2		2.0		0.18	0.14–0.32	0.48	
10	Bean, red kidney (P. vulgaris)	(0)		2		2.5		0.22		0.51	
11	Bean, snap, green and yellow (P. vulgaris)	0.38[2]	0.36–0.66	19	10–26	0.5		0.11		0.08	
12	Beet, garden (Beta vulgaris)	0.01		10	3–15	0.4	0.1–0.6	0.05	0.03–0.13	0.02	0.01–0.09
13	Beet greens (B. vulgaris)	4.02		34		0.4	0.3–0.6	0.18	0.17–0.63	0.08	0.04–0.10
14	Blackberry (Rubus spp.)	0.12	0.05–0.24	21	3–28	0.4		0.04		0.04	0.02–0.05
15	Blueberry (Vaccinium corymbosum)	0.17		16	7–22	(0.3)		(0.02)		(0.02)	
16	Brazil nut (Bertholletia excelsa)	Trace		2						0.86	0.50–1.10
17	Broccoli (Brassica oleracea botrytis)	2.10		118	50–172	1.1	0.8–1.4	0.21		0.10	
18	Brussels sprouts (B. oleracea gemmifera)	0.24	0.18–0.30	94	13–150	0.7		0.16	0.06–0.30	0.08	
19	Cabbage (B. oleracea capitata)	0.05		50	30–100	0.3	0.1–0.7	0.05	0.03–0.13	0.06	0.03–0.14
20	Cantaloupe (Cucumis melo cantalupensis)	2.05[3]		33	26–60	0.5		0.04	0.03–0.08	0.05	0.03–0.15
21	Carrot (Daucus carota)	7.20			2–10	0.5	0.2–1.5	0.06	0.04–0.09	0.06	0.03–0.14
22	Cashew nut, roasted (Anacardium occidentale)					2.1		0.19		0.63	
23	Cauliflower (Brassica oleracea botrytis)	0.05		69	37–94	0.6	0.5–0.7	0.10	0.05–0.22	0.11	0.10–0.20
24	Celery (Apium graveolens)	0		7	5–15	0.4		0.04	0.03–0.10	0.05	
25	Chard, leaves and stems (Beta vulgaris)	1.68		38		0.4		0.07		0.06	
26	Cherry, sour and sweet (Prunus spp.)	0.37	0.09–0.42	8	1–25	0.4		0.06		0.05	
27	Coconut (Cocos nucifera)	0		2		0.2		0.01		0.10	
28	Collard (Brassica oleracea acephala)	4.12		100		(2.0)		0.27		0.11	
29	Corn, sweet, white and yellow (Zea mays)	0.23[4]	0.17–0.36	12	8–43	1.7	0.7–2.6	0.12	0.05–0.14	0.15	0.12–0.19
30	Cranberry (Vaccinium macrocarpon)	0.02	0.01–0.04	12	10–15	0.1		(0.02)		(0.03)	
31	Cress, water (Radicula nasturtium aquaticum)	2.83		77	43–187	0.8		0.16	0.10–0.30	0.08	
32	Cucumber (Cucumis sativus)	0[5]		8	2–13	0.2	0.1–0.3	0.04	0–0.15	0.03	
33	Currant, red (Ribes rubrum)	0.07		36	15–45					0.04	0.03–0.05
34	Dandelion greens (Taraxacum officinale)	8.19	5.40–19.80	36	32–100	(0.8)		0.14		0.19	0.15–2.23
35	Date (Phoenix dactylifera)	8.23		(0)		2.2		0.10		0.09	0.06–0.10
36	Eggplant (Solanum melongena)	0.02	0.01–0.06	5	1–10	0.6		0.05	0.03–0.08	0.04	
37	Endive (Cichorium endivia)	1.80		11	10–27	0.4		0.12	0.06–0.24	0.07	0.06–0.09
38	Fig, dried (Ficus carica)	0.05		(0)		1.7		0.12		0.16	0.06–0.18
39	Fig, fresh (F. carica)	0.05	0.01–0.05	2		0.5		0.05		0.06	
40	Gooseberry (Ribes hirtellum)	0.17	0.07–0.23	33						[illegible]	0.04–0.15
41	Grape (Vitis spp.)[6]	0.05		4	2–6	0.2		.04	0–0.06	0.06	0.02–0.07
42	Grapefruit (Citrus grandis)	Trace		40	25–43	0.2		0.02		0.04	
43	Guava (Psidium guajava)	0.15		302	60–442	1.2		0.04	0.01–0.09	0.07	0.04–0.15
44	Honeydew melon (Citrullus sp.)	0.24		23		0.2		0.03		0.05	
45	Kale (Brassica oleracea acephala)	4.52	0.45–22.2	115	50–150	2.0		0.26		0.10	
46	Lemon (Citrus limonia)	0		50	29–60	0.1		Trace		0.04	0.02–0.09
47	Lettuce, headed (Lactuca sativa)	0.32	0.04–1.32	8	6–21	0.2		0.08	0.04–0.12	0.04	
48	Lime (Citrus aurantifolia)	0		27	23–38	(0.1)		(Trace)		(0.04)	0.03–0.06

/1/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene = 1 I U vitamin A. /2/ Applicable to green beans; yellow beans 0.09. /3/ Applicable to deeply colored varieties. /4/ Applicable to yellow corn; white corn, trace. /5/ Applicable to pared cucumbers; unpared, 0.16. /6/ Data applicable to both American and European types.

70 VITAMIN COMPOSITION FOODSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams per 100 grams of edible portion of fresh uncooked foodstuff unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses Ranges represent estimate d (cf Introduction) of the 95% range

	Foodstuff	Vitamin A as β-carotene[1] Value mg/100g	Vitamin A Range[4]	Ascorbic Acid Value mg/100g	Ascorbic Acid Range[4]	Niacin Value mg/100g	Niacin Range[4]	Riboflavine Value mg/100g	Riboflavine Range[4]	Thiamine Value mg/100g	Thiamine Range[4]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
49	Mango (Mangifera indica)	3.81		41	23–60	0.9		0.06	0.04–0.26	0.06	0.04–0.10
50	Mushroom (Agaricus campestris)	0		5	1–8	4.9		0.44	0.01–0.90	0 10	0.06–0.20
51	Mustard greens (Brassica japonica)	3.88	0.36–7 20	102	45–180	0.8		0.20		0.09	
52	Oats rolled (Avena sativa)	(0)		(0)		1.0		0 14		0.60	
53	Okra (Hibiscus esculentus)	0.44	0.18–1.44	30		1.1	0.7 1 1	0.07		0.08	
54	Onion immature green (Allium cepa)	(0.06)		24		(0.2)		(0.04)		(0.03)	
55	Onion, mature (A. cepa)	0.03		9		0.2		0.04		0.03	
56	Orange (Citrus spp.)	(0.11)	0.03–0.42	49	45–66	0.2		0.03		0.08	0.07–0.14
57	Parsley (Petroselinum hortense)	4.94	3–18	193		1.4		0.28		0 11	
58	Parsnip (Pastinaca sativa)	0		18		0.2		0.12		0.08	
59	Pea garden immature (Pisum sativum)	0.41	0.36–1 98	26	15–31	2.7		0.16	0.13–0.25	0.34	0.09–0.49
60	Pea garden mature dried (P sativum)	0.22		2		3 1		0.28	0.13–0.30	0.77	
61	Peach (Prunus persica)	0.53		8	7 10	0 9		0 05	0.02–0.06	0.02	0.01–0.07
62	Peanut roasted (Arachis hypogaea)	0		(0)		16 2	12 6–36	0.13		0.30	
63	Pear (Pyrus communis)	0.01		4	3–7	0 1		0.04	0.02–0.15	0 02	
64	Pecan (Carya illinoensis)	0 03		2		0.9		0 11		0.72	
65	Pepper green (Capsicum annuum)	0.38		120	90–180	0.4	0.2–4.9	0.07	0.04–0.18	0.04	0.02–0 07
66	Persimmon (Diospyros kaki)	1.63		11		Trace		0.05		0 05	
67	Pineapple (Ananas sativus)	0.08	0.02–0.09	24	13–30	0.2		0 02	0.01–0.08	0.08	0.05–0.13
68	Plum (Prunus spp.)	0.21	0.08–0.22	5	4–7	0.5	0.1–0 7	0.04	0.03–0.05	0.06	0.05–0.20
69	Potato (Solanum tuberosum)	0.01		17[7]	4–28	1.2	0.1 1.2	0.04	0.03–0.12	0.11	0.05–0.17
70	Prunes (Prunus spp.)	1.13	0.24–1.90	3	0–8	1.7		0.16	0.05–0.65	0 10	
71	Pumpkin (Cucurbita pepo)	(2 04)	1.20–5 32	8	3–10	(0 6)		(0 06)	0.04–0.09	(0 05)	
72	Radish (Raphanus sativus)	0 02		24	12–26	0.3		0.02		0.03	0 02–0.10
73	Raisins (Vitis vinifera)	0.03	0.01–0.06	Trace		0 5	0.1–0.6	0.08	0.03–0.13	0.15	0.07–0.20
74	Raspberry black (Rubus occidentalis)	0		(24)		(0.3)		(0.07)		0.02	
75	Raspberry red (R. strigosus)	0.08		24	8–38	(0.3)		(0.07)		0.02	0.01–0.09
76	Rhubarb stems only (Rheum rhaponticum)	0 02		9	6–29	0.1				0.01	
77	Rice brown (Oryza sativa)	(0)		(0)		4.6		0 05		0.32	
78	Rice white (O. sativa)	(0)		(0)		1.6		0 03		0.07	
79	Rutabaga (Brassica campestris)	0.20		36	20–45	0.9		0.08	0.05–0.10	0.07	
80	Rye whole grain (Secale cereale)	(0)		(0)		1.6		0.22		0.43	
81	Soybeans mature dried (Glycine soja)	0.07		Trace		2 3	1.9–4.3	0.31		1.07	0.11 1.38
82	Soybean sprouts (G. soja)	0.11		13		0.8		0.20		0.23	
83	Spinach (Spinacia oleracea)	5.65	5 04–15 0	59	15–77	0.6		0.20	0.16–0.40	0 11	0.04–0.15
84	Squash summer (Cucurbita pepo)	0.16	0.12–1.28	17	14–28	0.8		0 09	0.01–0 12	0.05	
85	Squash winter (C maxima)	2 97	1.20–4.20	8		0.5		0.12	0.04–0.25	0.05	
86	Strawberry (Fragaria spp.)	0.04	0.03–0.72	60	25–107	0.3		0.07	0 02–0.30	0 03	
87	Sweetpotato (Ipomoea batatas)	4.62[5]		22	7 33	0.6	0.5–1.3	0.05	0 04–0 10	0.09	0 04–0.14
88	Tangerine (Citrus reticulata)	(0.25)		31	23–50	0.2[1]		(0.03)		0.07	
89	Tomato (Lycopersicon esculentum)	0.66	0.30–1.20	23	21–27	0.5		0 04		0.06	0.04–0 12
90	Turnip (Brassica rapa)	Trace		28	20–32	0.5		0 07		0 05	0.03–0.09
91	Turnip greens (B. rapa)	5 72		136	30–240	0.8	0.6–0 9	0.46	0.35–0.75	0.09	
92	Walnut black (Juglans nigra)	0.04		0						0.33	
93	Walnut English (J regia)	0 02		3		1.2		0 13		0.48	0.30–0.60
94	Watermelon (Citrullus vulgaris)	0.35	0.03–0.92	6	6–8	0.2		0.05	0.01–0.07	0.05	0.03–0.06
95	Wheat hard red winter whole grain (Triticum vulgare)	(0)		(0)		4.3		0.12		0.52	

/1/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity 0 0006 mg β-carotene = 1 I U. vitamin A. /5/ Applicable to deeply colored varieties /7/ Year round average Recently harvested potatoes 24; after storage of 3 mo 18; after storage of 6 mo. 8

71 PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES TROPICAL AND SUBTROPICAL FRUITS

(For remaining columns of this table see page 126)

Values, with the exception of Calories are grams or milligrams per 100 grams of edible portion of fresh uncooked fruits. Ranges are estimates[a] (cf Introduction) of the 95% range

Foodstuff / Constituents	Energy Value[1]		Water[2]		Protein[3]		Fat		Total Carbohydrate		Crude Fiber		Ash		Calcium (Minerals)	
	Value	Range[4]	Value	Range[4]	Value	Range[4]	Value	Range[4]	Value	Range[4]	Value	Range[4]	Value	Range[4]	Value	Range[4]
	Cal/100g		g/100g		g/100g		g/100g		g/100g		g/100g		g/100g		mg/100g	
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
1 Avocado (Persea gratissima)	245		65		1.7	0.8-2.4	26.4		5.0	2.9-12.2	1.8	1.0-3.7	1.4	0.5-1.7	10	4-20
2 Banana (Musa paradisiaca sapientum)	88	42-364	75	58-81	1.2	0.8-4.5	0.2	0-1.0	23.0	10.9-38.1	0.6	0.2-3.2	0.8	0.4-3.3	8	1-19
3 Bullocksheart (Annona reticulata)	101	66-116	72	68-79	1.7	1.2-2.5	0.6	0.1-1.1	25.2	17.0-27.5	3.4	0.9-3.7	1.0	0.3-1.1	27	10-95
4 Carambola (Averrhoa carambola)	35		90		0.7		0.5		8.0		0.9		0.4		4	
5 Cashew apple (Anacardium occidentale)	50	33-55	86	84-89	0.7	0.3-1.0	0.2	0.1-0.5	12.8	8.7-13.1	0.9	0.4-3.1	0.3		8	1-5
6 Citron (Citrus medica)			87		0.5		Trace				1.1		0.4		37	
7 Coco plum (Chrysobalanus icaco)	48	32-51	86	84-89	0.4	0.3-0.5	0.1	0-0.2	12.6	8.6-13.2	1.0	0.6-1.3	0.9	0.4-1.0	31	22-43
8 Date (Phoenix dactylifera)	284		20		2.2		0.6		75.4		2.4		1.8		72	
9 Durian (Durio zibethinus)	144		63		2.5		3.1		30.4		1.7		1.1		9	
10 Fig fresh (Ficus carica)	79		78	67-90	1.4	1.3-2.1	0.4		19.6		1.7	1.3-2.2	0.6	0.5-0.9	54	37-78
11 Granadilla (Passiflora ligularis)	94		76	70-79	2.4	2.1-2.9	2.2	1.5-3.8	18.9		4.5	3.2-5.6	1.0		11	6-14
12 Grapefruit (Citrus grandis)	40	31-57	89	84-90	0.5	0.4-1.2	0.2	Trace-0.4	10.0	8.3-13.7	0.3	0-0.4	0.4	0.2-0.5	22	6-29
13 Guava (Psidium guajava)	70	29-118	81	66-89	1.0	0.1-1.5	0.6	Trace-1.0	17.2	7.9-29	5.5	0.6-8.9	0.7	0.1-1.0	30	23-52
14 Jack fruit seed (Artocarpus integrifolia)			48	42-49	5.4		0.3	0.2-0.4	46.2		1.6		2.1	1.1-3.5		
15 Lemon (Citrus limonia)	32	9-42	89	83-94	0.9	0.3-1.1	0.6	0-1.4	8.7	3.1-9.9	0.9	0-1.4	0.5	0.2-0.8	40	
16 Lime (C. aurantifolia)	37		86		0.8	0.3-1.2	0.1	Trace-0.3	12.3		0.9	Trace-1.7	0.8		40[4]	
17 Loquat (Eriobotrya japonica)	48		87		0.4		0.2		12.4		0.5		0.5		20	
18 Lychee (Litchi chinensis)	64		82		0.9		0.3		16.4		0.3		0.5		8	
19 Mango (Mangifera indica)	66	33-90	81	78-89	0.7	0.2-2.1	0.2	Trace-1.0	17.2	9.1-20.8	1.0	0.3-2.2	0.5	0.2-0.9	9	3-37
20 Mangosteen (Garcinia mangostana)	63		83		0.6		0.6		15.6		5.1		0.2		8	
21 Manzanilla (Crataegus pubescens)			76		0.7	0.6-0.8	0.3	0.2-0.4			2.0		0.7		83	74-91
22 Mora (Rubus costaricanus)			80		1.6		1.5				5.7		0.7		63	
23 Orange sour (Citrus aurantium)	44		88		0.7	0.8-1.0	0.1		11.2		2.0	1.8-2.2	0.5	0.4-0.7	42	33-82
24 Orange sweet (C. sinensis)	45	18-58	87	77-93	0.9	0.3-1.7	0.2	0-0.6	11.2	4.1-13.3	0.6	0-3.7	0.5	0.3-0.6	33	4-56
25 Papaya (Carica papaya)	39	17-56	89	86-95	0.6	0.3-1.2	0.1		10.0	4.2-12.1	0.9	0.4-8.7	0.6	0.4-1.2	20	13-41
26 Persimmon (Diospyros kaki)	78		78		0.8		0.4		20.0		1.9		0.6		6	
27 Pineapple (Ananas sativus)	52	30-62	85	78-94	0.4	0.2-0.6	0.2	Trace-0.6	13.7	8.2-20.8	0.4	0.2-0.6	0.4	0.2-3.3	16	6-37
28 Pitanga (Eugenia uniflora)	51		86		0.8		0.4		12.5		0.6		0.5		9	
29 Plantain (Musa paradisiaca)	119	77-158	66	58-79	1.1	0.9-1.3	0.4	Trace-1.2	31.2	20.5-39.8	0.4	0.1-1.1	0.9	0.6-1.2	7	1-17
30 Pomegranate (Punica granatum)	63		82	74-86	0.5	0.4-1.6	0.3		16.4	12.4-20.9	0.2	0-5.3	0.5	0.3-0.8	3	

31	Prickly pear (Nopalea cochenillifera)			83		1.3		0.3				2 8		0.3		14	
32	Sapodill (Achras sapota)	89	29-166	76	55-90	0.9	0.3-3.1	1 1	0 1 1 8	21 8	7.4-39 5	1 4	0.7-3 9	0.5	0.1-6.2	21	4-121
33	Soursop (Annona muri ta)	65	49-74	82	77-84	1 0	0 2 1 7	0.3	0.1-0.8	16 3	13 1 17 0	1 1	0 8-1 8	0.7	0 4-0.9	14	
34	Spanish lime (Melicocca bijuga)	87	61 104	75	69-83	1 4	0 6-2 4	0 3	Trace-0.5	22 7	11 4-23 5	1 3	0.1-2 2	0.6	0.4-0.8	10	7 13
35	Starappl (Chrysophyllum cainito)	61	79-97	83	78-89	1 0	0.6-2 3	1 5	0 4-3.2	12 4	6.5-17 3	1 9		0 4	0 1-0 8	22	7-48
36	Sugarappl (Annona squamosa)	94		73		1 8	1 1 1 9	0.3		23 7		1 7	1 1-2 5	0 9	0.6-1 3	22	19-45
37	Tamarind (Tamarindus indic)	239		31	15-47	2 8	1 4-3.4	0.6	0.9-1 0	42.5		5.1		2 7	1 5-4.2	4	
38	Tomatillo (Physalis pubescens)			87	83-91	1 8	1 2-2 5	0 8	0.1 1 6			2 7	1 5-5 3	0 9	0 6-1.2	11	5-17
39	West Indian cherry (Malphigi punicifolia)	49	22-60	86	82-94	1 4	0.6-1 8	0.2	0.1-0.3	11 8	5 3-14.4	1.0	0 9-1.2	0 6	0.3-0.8	19	8-35
40	Zapote (Calocarpum mammosum)			63	55-73	1 6	1.2-2 1	0.5	0.2-0.8			2 1	1 4-3.1	1 2	0 9-1 6	39	26-56

/1/ Kilocalories Calculated by protein (col F,G) 3.36; fat (col H I) 8 37; omitting values 16 HC and 17 HC total carbohydrat (col. J,K) 3 60. For lemon and lime (lines 16,17) total carbohydrate 2.70 /2/ Values of 25 or above are rounded to nearest whol number /3/ Calculated by: total nitrogen 6 25 /4/ Based on inadequate evidence.

71 PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES TROPICAL AND SUBTROPICAL FRUITS (Continued)

Values with the exception of Calories are grams or milligrams per 100 grams of edible portion of fresh uncooked fruits Ranges are estimate "a (cf Introduction) of the 95% range

Constituents / Foodstuff	Mineral (Concluded)				Vitamins									
	Iron		Phosphorus		Vitamin A as β-Carotene[5]		Ascorbic Acid		Niacin		Riboflavine		Thiamine	
	Value	Range[a]	Value	Range[a]	Value	Range[b]	Value	Range[a]	Value	Range[a]	Value	Range[a]	Value	Range[a]
	mg/100g		mg/100g		mg/100g		mg/100g		mg/100g		mg/100g		mg/100g	
(A)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(BB)	(CC)	(DD)	(EE)	(FF)
1 Avocado (Persea gratissima)	0 6	0.4-2 1	38	21-64	0.17	0 03-0.48	16	5-33	1 1	0 8-2.9	0 13	0.07-2 0	0 06	0.03-0.88
2 Banana (Musa paradisiaca sapientum)	0 6	0.2-5 2	28	16-50	0.26	0-1 95	10	2 36	0.7	0.4-1.1	0 05	0.01-0.07	0 04	0.02-0.07
3 Bullocksheart (Annona reticulata)	0.8	0 4-3 6	20	6-36	Trace	0-0.02	32	15-44	0.5		0 10	0.09-0.18	0 08	0 07-0.19
4 Carambola (Averrhoa carambola)	1 5		17		0.73		35		0 3		0.02		0 04	
5 Cashew apple (Anacardium occidentale)	0.4	0.2-0 7	20	15-21	0 49	0.24-0 74	219	147-348	0 5		0.02		0 02	
6 Citron (Citrus medica)	0 6		16				37		0.1		0 03		0.05	
7 Coco plum (Chrysobalanus icaco)	0.6	0 4-0.9	17	10-20	0.01		8	5-11	0.4	0 2-0.6	0 03	0 02-0.05	0 03	0.01-0 05
8 Date (Phoenix dactylifera)	2 1		60		0.04		0		2.2		0 10		0 09	
9 Durian (Durio zibethinus)	0 9		44		0.02		24		0 7		0.20		0.24	
10 Fig fresh (Ficus carica)	0.6		32	29-33	0.05		2		0 5		0 05		0.06	
11 Granadilla (Passiflora ligulari)	1.2	0 6-1 6	61	44-78	0 01		17	11-28	1.4	1 2-1.8	0 10	0.07-0 13	Trace	
12 Grapefruit (Citrus grandis)	0.2		18	12-48	Trace		40	23-50	0.2	0.1-0.7	0.02	0.01-0 05	0.04	0 02-0.06
13 Guava (Psidium guajava)	0 7	0.3-2.9	29	18-59	1.20		302		1.2	0.6-2.4	0.10		0.07	
14 Jack fruit seed (Artocarpus integrifoli)														
15 Lemon (Citrus limoni)	0 6	0.3-5 8	22	7-27	0		50	19-71	0 1	Trace-0.2	Trace		0 04	0.01-0.09
16 Lime (C aurantifoli)	0 6[h]	0.2-3 9	22[h]	9-23	0		27		0.1		Trace		0 04	0.01-0.07
17 Loquat (Eriobotrya japonica)	0.4		36		0 40		Trace							
18 Lychee (Litchi chinensis)	0.4		42				42				0.05			
19 Mango (Mangifera indica)	0.2		13	5-62	3 81		41	26-172	0.9		0 06	0.02-0 17	0.06	0.01-0.12
20 Mangosteen (Garcini mangostana)	0.8		12				2						0.03	
21 Manzanilla (Crataegus pubescens)	2 1	1.6-2 6	16	13-18	0.32	0.11-0.54	91	90-93	0.3		0 03			Trace-0.03
22 Mora (Rubus costaricensis)			35				21		0.4		0.06		0 02	
23 Orange sour (Citrus aurantium)	0.4	0.2-0.9	20		0.07	0.06-0.29	43		0.3	0 2-0.4	0.03		0.07	0.05-0.09
24 Orange sweet (C sinensis)	0.4	0.2-2 7	23	9-28	0 11[h]	0-0.24	49	37-80	0 2	0 1-0 5	0.03	0 01-0.06	0 08	0.04-0.13
25 Papaya (Carica papaya)	0.3		16	4-23	1.05	Trace-1 41	56	36-71	0 3	0 2-0 6	0.04	0.02-0.06	0.03	0.01-0.08
26 Persimmon (Diospyros kaki)	0 3		26		1 03		11		Trace		0.05		0.05	
27 Pineapple (Ananas sativus)	0 3		11	5-28	0 05	Trace-0.18	24	10-165	0.2	0 1-0.3	0 02		0 08	0 04-0 14
28 Pitanga (Eugeni uniflora)	0.2		11				30							
29 Plantain (Musa paradisiaca)	0.7	0.3-4.9	30	16-79	0.01[6]	0.003-0.90	14	6-26	0 6	0.4-0.9	0 04	0 02-0 07	0.06	0.03-0.15
30 Pomegranate (Punica granatum)	0.3	0.7-1.2			0		10	4-12	0.3		0 01		0.02	Trace-0.03

31 [illegible]	0.3		81		Trace		17		0 3		0 05		0 01	
32 Sapodilla (Achras sapota)	0.8	0.2 3 1	12	6–38	0.04	0–1 44	14	1–40	0 2		0.02	0–0.07	Trace	0–0 03
33 Soursop (Annona muricata)	0.6	0.2 1 3	27		0 07		20	16–26	0 9	0.6–1 7	0 05	0.03–0 12	0.07	0.04–0.12
34 Spanish lime (Melicocca bijuga)	2 6	0 5–5 9	39	24–30	0.03	0.02–0 04	8	3–11	1 2	0.7–2 0	0 04	0 02–0.08	0.02	
35 Starapple (Chrysophyllum cainito)	1 4	0.3–6.6	18	13–22	0.01	0–0.04	9	3–16	1 0	0.6–1 8	0.02	0 01–0.04	0.02	0–0.07
36 Sugarapple (Annona squamosa)	0.6	0 3–1 0	41	24–35	0 01		34		1 0	0.7 1 3	0.14	0 11–0 17	0.10	
37 Tamarind (Tamarindus indica)	0.6		113		0.02		2		1 2	1 1 1 7	0.14	0.09–0 18	0.34	0.30–0 59
38 Tomatillo (Physalis pubescens)	1 0	0.6–1 3	35	25–49	0.12	0 03–0 31	8	3–12	3 5	2.0–6.8	0.04	0 03–0.06	0 12	0.05–0 21
39 West Indian cherry (Malphighia punicifolia)	1 5	1.0–2 3	76	7 33	0 02	Trace–0.04	2142	577 3307	0 5		0 07	0 06–0.09	0.02	0.01–0.03
40 Zapote (Calocarpum mammosum)	1.0	0 5–2 6	27	4–33	0 22	0.07–0 52	20	9–40	2 0	1 6–2.6	0 02	0 01–0.03	0.01	0–0 03

/4/ Based on inadequate evidence /5/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity 0 0006 mg β-carotene = 1 I. U. vitamin A. /6/ Applicable to white flesh varieties; for yellow varieties 0 72

72 RELATIVE PRODUCTION OF NUTRIENTS: FOODSTUFFS OF PLANT ORIGIN

Data are average yields and derived values per acre (1 acre 0.471 hectares) of land used to produce the specified food crops. Yields at retail sal (col C) do not include an allowance for the value of by-products (e. g. wheat used for white flour also yields bran as a by-product). Values for nutrients, calculated from col C represent the number of days a moderately active man can be supplied with a suitable daily allowance of the given nutrient by the yield of one acre of the foodstuff. Data for carbohydrates are not available.

	Food Product	Yield		Days of Adequate Supply of[1]									
		Quantity at Harvest	Quantity at Retail Sale[2]	Food Energy	Protein	Fat	Calcium	Iron	Vitamin A	Ascorbic Acid	Niacin	Riboflavine	Thiamine
		lb/acre[3]	lb/acre[3]	da	da	da	da	da	da	da	da	da	da
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
	Fresh Vegetables[4]												
1	Asparagus (Asparagus officinalis)	2 448	2 227	67	299	21	198	575	1 528	5 556	579	697	808
2	Bean lima (Phaseolus lunatus mac)	2 112	1 945	154	378	39	279	680	202	1 503	220	253	585
3	Bean, snap (P vulgaris)	2 700	2 403	158	356	26	799	901	1 230	2 531	401	495	515
4	Beet garden (Beta vulgaris)	9 516	8,565	442	661	34	985	2 426	157	3 882	799	728	628
5	Cabbage (Brassica oleracea cap)	13 840	11 764	375	775	110	2 235	1,662	635	27 155	706	1 236	1 804
6	Cantaloupe (Cucumi melo cantal)	6 660	5 661	90	105	30	255	424	8 234	5 208	642	227	452
7	Carrot (Daucus carota)	16 550	14 715	878	1 009	235	2 869	3 924	141 265	4 709	1 962	1 914	2 649
8	Cauliflower (Brassica oleracea bot)	10 804	9 291	195	650	50	525	1 705	571	17 468	743	1 022	1 501
9	Celery (Apium graveolens)	27 300	24 570	516	1 299	197	4 392	2 861	0	6 552	1 474	1 474	1 474
10	Corn sweet (Zea mays)	3 491	3 002	187	274	84	60	226	409	801	480	360	541
11	Cucumber (Cucumi sativus)	5 136	4 417	68	159	18	177	368	0	1 590	147	619	333
12	Eggplant (Solanum melongena)	7 590	6 603	245	406	71	487	880	132	1 673	1 409	726	1 189
13	Kale (Brassica oleracea acephala)	6 876	5 570	267	899	127	4 560	2 971	24 450	24 877	891	2 813	1 300
14	Lettuce (Lactuca sativa)	10 710	8 675	165	471	70	748	1 157	2 967	2 776	289	911	1 157
15	Onion (Allium cepa)	12 900	11 094	769	951	155	1 900	1 942	466	5 621	444	555	1 110
16	Pea garden (Pisum sativum)	2 610	2 479	170	486	27	140	806	690	1 786	694	459	1 190
17	Pepper green (Capsicum annuum)	5 650	5 086	190	354	55	267	635	2 451	50 984	474	433	916
18	Spinach (Spinacia oleracea)	3 816	3 091	95	380	45	1 163	2 885	21 661	9 025	536	1 391	907
19	Tomato (Lycopersicon esculentum)	6 201	4 650	141	266	74	255	930	4 074	5 767	775	572	744
20	Watermelon (Citrullus vulgaris)	6 975	6 068	132	87	33	114	202	1 505	1 052	162	334	404
	Canned Vegetables[4]												
21	Asparagus (Asparagus officinalis)	2 360	1 615	51	168	30	184	605	888	1 442	398	319	312
22	Bean, lima (Phaseolus lunatus mac)	1,116	1 590	174	395	30	245	1 020	188	763	233	175	169
23	Bean snap (P vulgaris)	5 340	4,523	152	291	0	695	2 411	1,701	1,086	452	498	422
24	Beet garden (Beta vulgaris)	14 120	4 688	275	301	0	398	1 055	75	1 313	157	305	156
25	Cabbage (Brassica oleracea cap)	16 840	12 967	389	926	155	3 387	2 485	130	15 852	865	5 900	1 210
26	Corn, sweet (Zea mays)	4 680	1,756	204	229	54	40	336	323	561	445	185	129
27	Pea garden (Pisum sativum)	1 790	2 551	265	561	62	364	1 742	1 260	1 326	697	352	816
28	Spinach (Spinacia oleracea)	4 380	4 946	185	735	118	2 528	3 009	30 500	4 353	462	940	296
29	Tomato (Lycopersicon esculentum)	10 220	4 476	144	283	53	279	1 007	4 271	4 476	954	336	686

	Fresh Fruits[3]												
50	Apple (Pyrus malus)	9 184	4 666	401	80	100	140	467	336	1 120	311	186	467
51	Apricot (Prunus armeniaca)	6 198	5 639	453	346	30	479	956	13 444	1 127	1 202	479	459
52	Avocado (Persea gratissima)	2 176	1 980	595	164	2 371	84	339	384	1 426	458	309	359
53	Blueberry (Vaccinium corymbosum)	916	888	98	34	32	81	257	229	877	77	134	71
54	Grape (Vitis spp.)	8,009	7 208	778	361	173	675	1 [illegible]	475	1 634	913	472	1 1[illegible]
55	Grapefruit (Citrus grandis)	21 390	20 320	901	455	163	1 295	1 [illegible]	[illegible]	[illegible]	523	610	1 430
56	Lemon, (C. limonia)	18,240	17 328	710	619	333	649	433	0	27 342	462	96	1 502
57	Lime (C. aurantifolia)	2 640	2 508	134	100	10	153	63	0	3 143	84	25	257
58	Orange (C. spp.)	14 800	14 060	769	582	131	1 838	1 [illegible]	1 [illegible]	3 [illegible]	[illegible]	[illegible]	2 [illegible]
59	Peach (Prunus persica)	5 760	5 126	449	146	87	205	1 025	3 619	2 119	1,230	43	273
60	Pear (Pyrus communis)	8 700	7 830	684	791	157	480	715	141	1 570	241	425	41
61	Plum (Prunus spp.)	5 600	4 984	402	214	60	493	914	1 [illegible]	1 529	[illegible]	224	2 [illegible]
62	Strawberry (Fragaria spp.)	2 241	2 017	120	101	70	458	593	101	7 019	173	272	173
	Dried Fruits[3]												
63	Apple, nuggets (Pyrus malus)	5 184	318	306	47	31	71	604	0	46	79	70	33
64	Apricot (Prunus armeniaca)	6 192	1 207	333	407	23	393	2 2[illegible]	8 143	318	1 [illegible]	443	43
65	Prune (P. spp.)	5 600	2 240	861	289	69	582	2 800	3 [illegible]	429	936	[illegible]	[illegible]
66	Raisin (Vitis spp.)	8,009	2 003	904	297	61	886	2 503	92	0	274	370	321
	Nuts[5]												
67	Almond (Amygdalus communis)	516	464	230	257	777	342	95	0	0	445	350	177
68	Pecan (Carya pecan)	128	102	60	52	235	22	49	2	3	14	14	145
69	Walnut (Juglans spp.)	912	730	348	319	1 278	154	261	10	53	117	38	47[illegible]
	Grain[6]												
70	Barley pearl (Hordeum vulgare)	1,166	642	547	541	39	39	486	0	0	604	119	235
71	Buckwheat flour (Fagopyrum esculentum)	870	487	261	198	32	31	183	0	0	509	57	458
72	Corn yellow meal (Zea mays)	1 837	1 312	725	773	294	156	1 344	611	0	815	492	1 [illegible]
73	Oats oatmeal (Avena sativa)	1,040	428	237	495	191	232	842	0	0	145	135	711
74	Rice brown (Oryza sativa)	2 007	1 385	853	772	169	331	3 303	0	0	2 188	174	1 406
75	Rice white (O. sativa)	2 007	1 385	704	654	24	68	353	0	0	537	79	212

/1/ Computed by dividing nutrient content of food at retail (col. C) by daily allowances of food nutrients for a moderately active man as recommended by the National Research Council /2/ Determined as recommended by U S Dept Agr Conversion factors and weights and measures for agricultural commodities and their products 1944 No allowance is made for loss in nutrient content of food after it leaves retail stores or from waste in home preparation /3/ Pounds per acre x 0 18356 Kg per hectare /4/ U S average yields from 1936-1945 /5/ U S average yields from unspecified period /6/ U S average yields from 1941 1945

72 RELATIVE PRODUCTION OF NUTRIENTS FOODSTUFFS OF PLANT ORIGIN (Concluded)

Data are average yields and derived values per acre (1 acre = 2.471 hectares) of land used to produce the specified food crops Yields at retail sale (col. C) do not include an allowance for the value of by products (e g. wheat used for white flour also yields bran as a by-product) Values for nutrients calculated from col C represent the number of days a moderately active man can be supplied with a suitable daily allowance of the given nutrient by the yield of one acre of the foodstuff Data for carbohydrates are not available

	Food Product	Yield: Quantity at Harvest	Yield: Quantity at Retail Sale[2]	Days of Adequate Supply of[1]: Food Energy	Protein	Fat	Calcium	Iron	Vitamin A	Ascorbic Acid	Niacin	Ribo-flavine	Thiamine
	(A)	lb/acre[3] (B)	lb/acre[3] (C)	da (D)	da (E)	da (F)	da (G)	da (H)	da (I)	da (J)	da (K)	da (L)	da (M)
	Grain 6												
56	Rye light flour (Secale cereale)	706	537	891	909	30	55	264	0	0	147	84	244
57	Rye whole flour (S cereale)	706	668	364	489	69	231	1,219	0	0	352	313	948
58	Wheat white flour (Triticum vulgare)	1 062	754	409	327	41	81	189	0	0	176	57	151
59	Wheat whole flour (T vulgare)	1 062	1 041	566	677	106	285	1 500	0	0	1 756	891	1 756
	Other Staple Crops 6												
60	Bean dried (Phaseolus spp)	889	782	414	1,116	71	696	3 050	0	83	500	419	1,413
61	Beet brown sugar (Beta vulgaris)	24 800	3 894	2 249	0	0	1 673	3 823	0	0	0	0	0
62	Beet granulated sugar (B vulgaris)	24 800	3 646	2 199	0	0	0	145	0	0	0	0	0
63	Pea, garden dried (Pisum sativum)	1 328	1 124	602	1 789	67	465	2 548	378	141	1 094	731	2 953
64	Peanut butter (Arachis hypogaea)	668	581	339	645	1 099	160	272	0	0	1,862	136	225
65	Potato (Solanum tuberosum)	8 328	7 449	806	812	43	391	1,674	104	6 404	2 183	561	1 985
66	Soybean (Glycine soja)	1,092	983	321	2 224	1 078	1,267	2 973	96	0	618	686	3 394
67	Sweetpotato (Ipomoea batatas)	4 918	4,224	687	421	151	620	949	25 369	4 846	789	486	1,041
68	Sugarcane brown sugar (Saccharum officinarum)	41 200	3 317	1 985	0	0	1 442	3 262	0	0	0	0	0
69	Sugarcane granulated sugar (S officinarum)	41 200	3 098	1 868	0	0	0	137	0	0	0	0	0

/1/ Computed by dividing nutrient content of food at retail (col C) by daily allowances of food nutrients for a moderately active man, as recommended by the National Research Council /2/ Determined as recommended by U S Dept Agr Conversion factors and weights and measures for agricultural commodities and their products 1944 No allowance is made for loss in nutrient content of food after it leaves retail stores or from waste in home preparation
/3/ Pounds per acre x 0.18356 Kg per hectare /6/ U S average yields from 1941 1945

73 AMINO ACID COMPOSITION CERTAIN PROTEIN FOODS

This table presents the best average values obtained from a study of the reports of analyses from 11 laboratories The foodstuffs for analysis were prepared by a central source, and uniform samples of acid and alkaline hydrolysates and of the dried foods were distributed to the cooperating laboratories All values are in terms of mg amino acid per 100 mg nitrogen present in the purified protein

	Amino Acid	Beef Muscle[1] mg/100 mg N	Casein[2] mg/100 mg N	Egg Albumin[3] mg/100 mg N	Egg Powder[4] mg/100 mg N	Peanut Flour[5] mg/100 mg N	Wheat Gluten[6] mg/100 mg N
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Arginine	40 2	24 4	37 4	38 9	70 5	23 0
2	Aspartic acid	58 4	45 5	68 7	67 3	81 1	23 6
3	Cystine	8 4	2 5	18 6	14 3	9 0	14 8
4	Glutamic acid	91 5	139 9	80 6	78 5	114 5	218 7
5	Glycine	35 2	12 4	23 5	24 7	33 6	20 7
6	Histidine	20 5	19 0	15 1	13 2	13 9	12 4
7	Isoleucine	32 3	39 7	40 3	38 6	25 9	28 4
8	Leucine	48 8	62 6	54 8	56 4	44.2	45 0
9	Lysine	53 7	50 6	45 0	38 3	21 8	12 6
10	Methionine	16 9	20 5	26 0	20 1	5 2	10 4
11	Phenylalanine	24 3	33 8	37 1	35 3	30 7	31 5
12	Proline	32 1	83 5	26 8	28 0	31 0	88 3
13	Threonine	27 8	28 1	30 5	30 9	17 4	17 5
14	Tryptophan	6 3	6 0	7 2	7 1	4 9	4 8
15	Tyrosine	18 5	32 2	20 8	22 1	18 1	17.4
16	Valine	32 1	46 0	46 6	43 7	28 5	26 6

/1/ Utility grade beef trimmed free from fat ground vacuum-dried defatted with benzol, vacuum-dried again and powdered; contains 15 97% N on ash and moisture-free basis /2/ Purified from acid-precipitated casein dried in air at 60-70 C and powdered; contains 15 23% N on ash and moisture-free basis No alcohol or other organic solvents used in purification process /3/ Egg white cultured to remove natural sugar dried at about 60° C, and powdered; contains 14 21% N, on ash and moisture-free basis /4/ Whole fresh eggs defatted with ethylene dichloride, dried and powdered; contains 13 96% N on ash and moisture-free basis /5/ Spanish peanuts dried with strict temperature and moisture controls and powdered; contains 10 51% N on ash and moisture-free basis /6/ Wheat gum gluten flour washed several times with cold water vacuum-dried and powdered; contains 14 34% N, on ash and moisture-free basis

74 PROXIMATE CHEMICAL COMPOSITION ENERGY VALUES AND DIGESTIBLE NUTRIENTS FEEDSTUFFS OF ANIMAL ORIGIN

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition see page 133

	Feedstuff / Constituents	Water	Dry Matter	Crude Protein[2]	Crude Fat[3]	Total Nutrients: Total Carbohydrate[4] Crude Fiber	Total Nutrients: Total Carbohydrate[4] N-Free Extract	Ash	Digested (ible) Nutrients[1]: Protein	Digested: Fat	Digested: Total Carbohydrate[4] Fiber	Digested: Total Carbohydrate[4] N-Free Extract	"Total Digestible Nutrients"[5]	Digested (ible) Calories[6]	Metabolizable Calories[7]
		g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
1	Blood flour	7 8	92 2	84.7	1 0	1.1	0 7	4.7	81 3				82 4	361	330
2	Blood meal	8 2	91 8	84.5	1 1	1 0	0 7	4.5	60 0[8]	0 4[9]	0 2	0 2[10]	72.2	339	289
3	Bone meal raw	6 4	93 6	26.0	5 0	1 0	2 5	59 1	17 7	5 9[11]	0	0	10 2	45	41
4	Bone meal steamed	3 7	96 3	7 1	3 3	0 8	3 8	81 3					15[12]	66	60[12]
5	Buttermilk dried	7 6	92 4	32 4	6.4	0.3	43 3	10 0	29.2[13]	6 5[14]	0	40 7[15]	85 3[16]	390	340
6	Crab meal	7 9	92 1	31 5	2.2	10.5	6.0	41 9	25 5				29 6	130	118
7	Fish meal 63% protein	6 9	93 1	60 9	8 1	0 8	3 5	19 8	54 8[17]				74 2[18,19]	325	297[20]
8	Fish meal menhaden	6 4	93 6	62 2	8.5	0.7	4.2	18 0	50 2	9 8[21]	0	0	70 9	369	264
9	Fish meal sardine	6 9	93 1	67 2	5 0	0 6	5 4	14.9	55 1	5 0			68.9	302	276
10	Fish meal white fish	9 6	90 4	63 0	6.7	0.1	0.1	20.5	58.6	6 0	0	0	72 2	387	289
11	Meat scrap 55% protein	6 9	93 1	52 9	7 3	2 2	4.3	26.4	43.4[22]				61 5[23]	269	246
12	Meat & bone scrap 50% protein	6.4	93 6	50 6	10.0	2 0	2.0	29 0	41 5				64 5[24]	282	257[25]
13	Milk cow's	87 2	12 8	3 5	3 7	0	4.9	0 7	3 2[26]	3 7[21,27]	0	4.9[27,28]	16 6	73	66
14	Milk skimmed dried	5 8	94.2	34.7	1 2	0.2	50.3	7 8	31 2[29]	1 2[21,30]	0	46 8[31]	80 7[32,33]	379	323[34]
15	Tankage digester 50% protein	6 5	93 5	51 3	11 5	2 3	2 3	26 1	43 6				66 4	291	266
16	Tankage digester 55% protein	5 9	94 1	56 0	10 2	2 3	2 2	23 4	47 6				67 9	297	272
17	Tankage digester 60% protein	7 9	92 1	60.6	8 5	2.0	1 8	20.2	51 5	7 2	0 1	0 3	68 4[35]	360	274[36]
18	Whey dried	6.5	93 5	12.2	0.8	0 2	70 4	9 9	11.0				78.3[37]	343	313[38]

/1/ Quantity ingested minus quantity in feces i e disappears from alimentary canal. Values are for ruminants and horses except as otherwise specified. /2/ Obtained by multiplying total nitrogen by a factor usually 6 25 /3/ Ether extract of finely ground feedstuff material /4/ Include fiber (cellulose lignin) and N-free extract (remainder of carbohydrate organic acids) /5/ Total digestible nutrients" (TDN) as commonly calculated 1 x col. I 2 25 col J 1 col K 1 x col L. /6/ Feed Calories minus fecal Calories i e virtually absorbed Calories before subtraction of urinary loss. Factors used are protei (col I) 5 65; fat (col J) x 9 5; carbohydrate (col. K,L) x 4 1 Where data on individual digested(ible) nutrients (col I L) are not availabl feed alories are calculated as TDN 4 58 (B. H. Schneider) /7/ Net physiologi al Calories availabl for heat activity and growth. Metabolizable energy bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane) energy lost in feces and energy lost in urine Factor used 1 : TDN (col M) x 4 0 Another factor proposed for use with TDN is 3 6 (H. H. Mitchell) /8/ Chicken 74 4 /9/ Chicken 1 0 /10/ Chicken 0 5 /11/ The physiological effects of some feedstuff tend to greatly stimulate the excretion of metabolizable products such as nitrogen or fat and the digestibility of the basal ration is adversely affected The negative sign therefore indicates the net negative contribution to the economy of the animal. /12/ For swine /13/ Chicken 26 6. /14/ Chicken 5 /15/ Chicken 35 1. /16/ Chicken 72. /17/ Chicken: protein 55.4; fat 7 6. /18/ Swine 73 /19/ Chicken 72. /20/ Swine 292 /21/ The physiological effects of some feedstuffs tend to greatly increase the digestibility of one or more nutrient to an amount of 100% or more /22/ Chicken: protein 47 6; fat 6 8 /23/ Chicken, 70 /24/ Swine 67 /25/ Swine 268. /26/ Chicken 3 3 /27/ Chicken, 3.7. /28/ Chicken, 4 9 /29/ Chicken, 31 /30/ Chicken, 1 1 /31/ Chicken 42 8 /32/ Swine 86 /33/ Chicken 76 /34/ Swine 344 /35/ Swine 71. /36/ Swine 284 /37/ Swine 83 /38/ Swine 352

75 MINERAL AND VITAMIN COMPOSITION FEEDSTUFFS OF ANIMAL ORIGIN

Values are milligrams or grams per 100 grams of feedstuff as fed

	Feedstuff / Constituents	Minerals					Vitamins				
		Calcium	Copper	Iron	Manganese	Phosphorus	Vitamin A as β-Carotene/1/	Niacin	Pantothenic Acid	Riboflavine	Thiamine
		g/100g	mg/100g	mg/100g/2/	mg/100g	g/100g	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Blood flour	0 64	0 90	295	0 64	0 48		2 91	0 55	0 64	0 04
2	Blood meal	0 30	1 00	421	0	0 21		0 31	0 11	2 70	
3	Bone meal raw	21 72	1 87	44	0 42	10 01		0 42	0 22	0 11	0 02
4	Bone meal steamed	29 30	1 98	88	1 12	15 10		0 44	0 18	0 08	0 20
5	Buttermilk, dried	1 35			0 33	0 94		0 62	2 97	3 48	0 37
6	Crab meal	14 50	3 39	810	5 99	1 50			0 66	0 51	
7	Fish meal, 65% protein	5 70				3 30					
8	Fish meal, menhaden	5 00	0 86	57	2 20	3 40		5 73		0 53	0 04
9	Fish meal, sardine	4 21	2 02	30	2 27	2 54		5 73	0 29	0 55	0 04
10	Fish meal, white fish	6 76			1 10	3 69		7 92		0 88	0 09
11	Meat scrap, 52% protein	8 70	1 21	50	0 88	4 40		5 96	0 46	0 53	0 007
12	Meat & bone scrap, 50% protein	9 70			1 17	4 20		4 71	0 33	0 46	
13	Milk, cow s	0 12			0 004	0 09	0 09	0 18	0 29	0 18	0 04
14	Milk, skimmed, dried	1 27	1 15	5 4	0 26	1 10		1 25	3 52	2 20	0 33
15	Tankage digester, 50% protein	10 97				5 14					
16	Tankage digester, 55% protein	7 90	2 00	152	0 70	4 30		2 88	0 15	0 15	0
17	Tankage digester, 60% protein	5 60	4 38	231	2 22	2 80		4 03	0 24	0 24	0 03
18	Whey, dried	0 91	5 33	21 2	0 24	0 75		1 12	4 93	2 86	0 40

/1/ 0 0006 mg β-carotene = 1 I U vitamin A /2/ Values of 25 and above are rounded to the nearest whole number

76 PROXIMATE CHEMICAL COMPOSITION ENERGY VALUES AND DIGESTIBLE NUTRIENTS FEEDSTUFFS OF PLANT ORIGIN

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition see page 136ff

Feedstuff \ Constituents	Water	Dry Matter	Total Nutrient: Crude Protein[2]	Total Nutrient: Crude Fat[3]	Total Nutrient: Total Carbohydrate[4]: Crude Fiber	Total Nutrient: Total Carbohydrate[4]: N-Free Extract	Total Nutrient: Ash	Digested(ible) Nutrients[1]: Protein	Digested(ible) Nutrients[1]: Fat	Digested(ible) Nutrients[1]: Total Carbohydrate[4]: Fiber	Digested(ible) Nutrients[1]: Total Carbohydrate[4]: N-Free Extract	Digested(ible) Nutrients[1]: "Total Digestible Nutrient"[5]	Digested(ible) Calories[6]	Metabolizable Calories[7]
	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
Concentrates														
1 Alfalfa meal dehydrated 17% protein	6.7	93.3	17.8	2.8	24.2	39.7	8.8							
2 Alfalfa meal dehydrated 20% protein	7.1	92.9	20.9	2.9	19.8	38.2	11.1	14.4	0.9	6.5	26.0	50.5[8]	231	202[9]
3 Alfalfa meal sun-cured 17% protein	7.8	92.2	17.6	2.0	23.8	38.9	9.9							
4 Barley excluding Pacific coast	10.6	89.4	12.7	1.9	5.4	66.6	2.8	10.0[10]	1.5[11]	3.0[12]	61.3[13]	77.7[14]	334	311[15]
5 Barley Pacific coast	11.0	89.0	9.7	2.2	6.2	68.7	2.2	7.7	1.8	3.5	63.2	78.3[14]	334	313[15]
6 Beet pulp molasses dried	8.1	91.9	10.7	0.7	16.0	59.4	5.1	7.1	0.6	12.6	53.5	74.6	317	298
7 Brewers dried yeast	6.3	93.7	46.8	1.2	2.8	35.7	7.2	40.2				71.7	314	287
8 Brewers grains, dried 25% protein	7.1	92.9	27.6	6.5	14.3	40.9	3.6	20.4[16]	5.7[17]	6.6	24.9[18]	65.5	297	262
9 Citrus pulp, dried	9.9	90.1	5.9	3.1	11.5	62.7	6.9	3.9	1.2	8.4	58.9	74.0	309	296
10 Corn and cob meal (corn ears ground)	13.9	86.1	7.3	3.2	8.0	66.3	1.3	5.3				73.3	321	293
11 Corn, dent yellow	15.0	85.0	8.9	3.9	2.0	68.9	1.3	6.8[19]	3.5[20]	1.1[21]	64.1[22]	80.0[23]	338	320[24]
12 Corn gluten feed 27% protein	8.9	91.1	26.6	3.0	7.2	48.2	6.1	22.9				76.5	335	306
13 Corn gluten meal 41% protein	8.6	91.4	42.9	2.0	3.9	40.1	2.5	36.5	1.9	2.3	37.3	80.2	366	321
14 Cottonseed hulls	15.7	84.3	4.1	0.9	47.6	35.3	2.7	-0.6[25]	0.7	34.3	18.0	42.3	177	169
15 Cottonseed meal 41% protein	7.8	92.2	41.2	6.2	11.2	27.7	5.9	33.8	5.8	3.1	19.7	69.7[26]	338	279[27]
16 Distillers dried corn grains	7.1	92.9	28.3	8.8	11.4	41.9	2.5	20.7	8.5	9.5	33.1	82.4	371	330
17 Distillers dried corn grains with solubles	6.9	93.1	28.8	8.9	9.0	41.7	4.7	21.0				80.9	354	324
18 Distillers dried solubles	6.9	93.1	28.0	6.7	3.3	47.6	7.5	20.4				75.4[28]	330	302[29]
19 Hominy feed white 5% fat	10.1	89.9	10.8	5.7	4.7	66.0	2.7	7.7				82.9	363	332
20 Linseed oil meal 35% protein, old process	8.8	91.2	35.0	5.6	8.1	36.9	5.6	30.4	5.1	4.8	30.3	77.1[30]	363	308[31]
21 Molasses cane	26.0	74.0	2.9	0	0	62.1	9.0	0.1	0	0	55.9	56.0[32]	230	224[33]
22 Oats, excluding Pacific coast	9.6	90.2	12.0	4.6	11.0	58.6	4.0	9.5[34]	3.7[35]	3.1[36]	46.3[37]	67.3[38]	291	269[39]

/1/ Quantity ingested minus quantity in feces i e disappears from alimentary canal Values are for ruminant and horses except as otherwise specified /2/ Obtained by multiplying total nitrogen by a factor usually 6.25 /3/ Ether extract of finely ground feedstuff material /4/ Includes fiber (cellulose lignin) and N-free extract (remainder of carbohydrate organic acids) /5/ "Total digestible nutrients (TDN) as commonly calculated, = 1 x col I + 2.25 x col J + 1 x col. K + 1 x col. L. /6/ Feed calories minus fecal calories, i e. virtually absorbed calories before subtraction of urinary loss Factors used are: protein (col. I) x 5.65; fat (col. J) x 9 5; carbohydrate (col K, L) x 4 1 Where data on individual digested(ible) nutrients (col I-L) are not available feed calories are calculated as TDN x 4 38 (B H. Schneider) /7/ Net physiological Calories available for heat activity and growth. Metabolizable energy bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane) energy lost in feces and energy lost in urine Factor used is: TDN (col M) x 4 0 Another factor proposed for use with TDN is 3.6 (H. H. Mitchell). /8/ Swine 33 /9/ Swine 132 /10/ Chicken, 9 8 /11/ Chicken, 1.5 /12/ Chicken, 0 6 /13/ Chicken, 57 3 /14/ Swine, 78 /15/ Swine, 288 /16/ Chicken, 22 1 /17/ Chicken 5 9 /18/ Chicken, 31.9 /19/ Chicken, 7.1. /20/ Chicken, 3 4 /21/ Chicken 0 5 /22/ Chicken, 68 /23/ Swine 78 /24/ Swine 312 /25/ The physiological effects of some feedstuffs tend to greatly stimulate the excretion of metabolizable products such as nitrogen or fat and the digestibility of the basal ration is adversely affected. The negative sign, therefore indicates the net negative contribution to the economy of the animal /26/ Swine, 69 /27/ Swine 276 /28/ Swine, 65 /29/ Swine 252 /30/ Swine 71 /31/ Swine 284 /32/ Swine 58 /33/ Swine 232 /34/ Chicken, 8 5 /35/ Chicken, 3 7 /36/ Chicken, 2 5 /37/ Chicken, 42 8 /38/ Swine 63 /39/ Swine 252.

PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN (Continued)

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition see page 138ff

	Feedstuff / Constituents	Water	Dry Matter	Total Nutrients: Crude Protein[2]	Total Nutrients: Crude Fat[3]	Total Nutrients: Total Carbohydrate[4]: Crude Fiber	Total Nutrients: Total Carbohydrate[4]: N-Free Extract	Total Nutrients: Ash	Digested(ible) Nutrients[1]: Protein	Digested(ible) Nutrients[1]: Fat	Digested(ible) Nutrients[1]: Total Carbohydrate[4]: Fiber	Digested(ible) Nutrients[1]: Total Carbohydrate[4]: N-Free Extract	Digested(ible) Nutrients[1]: Total Digestible Nutrients[5]	Digested(ible) Calories[6]	Metabolizable Calories[7]
		g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
23	Oats Pacific coast	8 8	91 2	9 0	5 4	11 0	62 1	3 7	6 6	4.8	3 5	48.4	68.4[38]	295	274[39]
24	Peas field, seed	9 3	90.7	23.4	1 2	6 1	57 0	3 0	20 1	0.8	3 1	53.0	77 9	351	312
25	Rice bran	9.0	91.0	12 8	13 1	12 7	41 7	10 7	9 2	11.0	4 1	31 7	69 8[30]	301	277[31]
26	Rice grain brown	12 2	87 8	9 1	2 0	1 1	74.5	1 1	6 1	1 5	0 2	57 6	67 4	294	278
27	Rice polish	9 7	90 3	12 7	11 4	3 5	56.6	6 2	9 7[40]	10 0[41]	1 -[42]	49 7[43]	83 1[44]	357	33-[45]
28	Rye grain	10.5	89 5	12 6	1 7	2 4	70 9	1 9	10.0[46]	0 9[47]	-0 9[25] [48]	63 8[49]	75 3[23]	323	301 [24]
29	Sorghum milo	10.6	89 4	11 3	2 9	2 2	71 3	1 7	9 9	2 5	1 1	62 7	79 3[23]	341	31-[24]
30	Soybean grain	10 0	90 0	37 9	18 0	5 0	24 5	4.6	34 1[50]	16.2[51]	-0 1[25] [52]	15 4[53]	85 8	406	345
31	Soybean oil meal 41% protein	10 2	89 8	41 1	5 3	5 5	30 4	7 5	34.5				76.4	335	306
32	Soybean oil meal 44% protein	9 2	90 8	44.2	5 3	5 6	29 9	5 8	37 1				78.6[54]	344	314[55]
33	Soybean oil meal solvent extract	9 4	90.6	46.1	1 0	5.9	31 8	5 8	42 4	0 5	5.2	79 9	78 7	388	313
34	Wheat hard red winter	10 4	89 6	15.2	1 8	2 6	68 3	1 7	12 8[56]	1 3[57]	1 8[58]	62 2[59]	80.0[60]	349	320[61]
35	Wheat soft Pacific coast	10 8	89.2	9 9	2 0	2 7	72 7	1 9	8.3				80.0	350	320
36	Wheat bran	10 3	89 7	16.4	4.3	9 9	53 0	6 1	12 5[62]	2 8[63]	3 6[64]	39 -[65]	61 3[66]	272	45[67]
37	Wheat flour middlings	10.3	89 7	18.1	4.6	4 9	58 5	3 6	14.7	3 8	1.2	49 7	74.2	327	297
38	Wheat screenings	9 6	90 4	13.9	4.7	9 0	58.2	4 6	10.0	4.1	0 5	48.9	73 5	297	294
39	Wheat standard middlings	9 9	90 1	17 6	5 0	6 7	56 6	4 2	13 7	4 5	2 5	42 5	68.5[68]	299	274[69]
	Dry Roughages														
40	Alfalfa hay	9 5	90.5	14.8	2 0	28.9	36.6	8.2	10 5	0.6	12 7	25 6	50.3	222	201
41	Alfalfa hay dehydrated	8 0	92 0	16.1	2 4	26.9	39 5	7 1	11 3	1 1	13 2	8 4	57 4	45	222
42	Alfalfa leaf meal good	7 7	92.3	21 2	2 8	16.6	39 7	12 0	16 1				54.7	248	227

/1/ Quantity ingested minus quantity in feces i e disappears from alimentary canal Values are for ruminants and horses except as otherwise specified. /2/ Obtained by multiplying total nitrogen by factor usually 6.25 /3/ Ether extract of finely ground feedstuff material /4/ Includes fiber (cellulose, lignin) and N-free extract (remainder of carbohydrate organic acids) /5/ "Total digestible nutrients (TDN) as commonly calculated 1 x col I + 2.25 x col J + 1 x col K + 1 x col L /6/ Feed calories minus fecal calori s i e virtually absorbed calories before subtraction of urinary loss Factors used are: protein (col I) x 5.65; fat (col J) x 9.3; carbohydrate (col K, L) x 4 1 Where data on individual digested(ible) nutrients (col I-L) are not available feed calories are calculated as TDN x 4 38 (B H Schneider) /7/ Net physiological Calori s vailable for heat, activity and growth Metabolizable energy = bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane) energy lost in feces and energy lost in urine Factor used is: TDN (col M) x 4 0 Another factor proposed for use with TDN is 3.6(H.H Mitchell) /23/ Swine 78 /24/ Swine 312 /25/ The physiological effects of some feedstuffs tend to greatly stimulate the excretion of metabolizable products such as nitrogen or fat and the digestibility of the basal ration is adversely affected The negative sign therefore indicates the net negative contribution to the economy of the animal /30/ Swine 71 /31/ Swine 284 /38/ Swine 63 /39/ Swine 292 /40/ Chicken 11 1 /41/ Chicken 5 7 /42/ Chicken, 1 6 /43/ Chicken, 54 9 /44/ Swine, 88 /45/ Swine 352 /46/ Chicken, 8 8 /47/ Chicken, 1 0 /48/ Chicken, 0 1 /49/ Chicken, 60 3 /50/ Chicken, 54.9 /51/ Chicken, 16.2 /52/ Chicken, 1 9 /53/ Chicken 10 6, /54/ Swine 79 /55/ Swine 316 /56/ Chicken, 13 4 /57/ Chicken 0 9 /58/ Chicken, 0 3 /59/ Chicken, 60 /60/ Swine 83 /61/ Swine 332 /62/ Chicken, 10.2 /63/ Chicken, 2 3 /64/ Chicken, 0 9 /65/ Chicken, 34.4 66 6 8 /68/ Swine 69 Swine 2

76 PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN (Continued)

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition, see page 138ff

Constituents / Feedstuff	Water	Dry Matter	Total Nutrients: Crude Protein[2]	Total Nutrients: Crude Fat[3]	Total Nutrients: Total Carbohydrate[4]: Crude Fiber	Total Nutrients: Total Carbohydrate[4]: N-Free Extract	Total Nutrients: Ash	Digested(ible) Nutrients[1]: Protein	Digested(ible) Nutrients[1]: Fat	Digested(ible) Nutrients[1]: Total Carbohydrate[4]: Fiber	Digested(ible) Nutrients[1]: Total Carbohydrate[4]: N-Free Extract	Digested(ible) Nutrients[1]: "Total Digestible Nutrients"[5]	Digested (ible) Calories[6]	Metabolizable Calories[7]
	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
43 Bluegrass hay Kentucky	15.7	84.3	9.5	2.3	25.2	40.1	7.2	5.4	1.2	16.9	25.7	50.3	216	201
44 Brome hay smooth	13.2	86.8	5.7	4.4	28.5	40.0	8.2	2.6	1.8	15.7	24.8	46.4	197	186
45 Bromegrass hay	11.9	88.1	9.9	2.1	28.4	39.5	8.2	5.0	0.8	16.8	25.3	48.9	208	196
46 Clover hay alsike	11.1	88.9	12.1	2.1	27.0	39.9	7.8	8.1	1.2	14.6	27.9	53.2	231	213
47 Clover hay crimson	10.5	89.5	14.2	2.2	27.4	37.0	8.7	9.8	1.0	12.9	24.1	48.9	216	196
48 Clover hay Ladino	12.0	88.0	19.4	3.2	20.7	34.9	9.8	14.2				54.9	240	220
49 Clover hay red	11.9	88.1	11.8	2.6	27.2	40.1	6.4	7.1	1.5	14.4	27.3	52.2	229	209
50 Clover and mixed grass hay high in clover	10.3	89.7	9.6	2.7	28.8	42.4	6.2	5.5	1.3	17.6	26.3	52.2	223	209
51 Clover and timothy hay 30-50% clover	11.9	88.1	8.6	2.2	30.3	41.2	5.8	4.8	1.2	17.3	26.4	51.2	217	205
52 Corn cobs ground	9.6	90.4	2.3	0.4	32.1	54.0	1.6	0	0.1	18.0	27.5	45.7	187	183
53 Corn fodder medium in water	17.4	82.6	6.8	2.1	21.8	46.7	5.2	3.3				53.9	236	216
54 Cowpea hay	9.6	90.4	18.6	2.6	23.3	34.6	11.3	12.3	1.2	11.9	24.4	51.4	230	204
55 Grass hay mixed	10.1	89.9	6.7	1.8	28.9	44.9	7.6	2.7	0.7	18.5	26.9	51.2	208	203
56 Lespedeza hay annual in bloom	10.9	89.1	13.0	1.8	26.5	42.7	5.1	6.5	0.6	12.7	26.9	47.5	215	190
57 Oat hay	11.9	88.1	8.2	2.7	28.1	42.2	6.9	4.9	1.8	14.3	24.1	47.3	202	189
58 Oat straw	10.3	89.7	4.1	2.2	34.1	41.0	6.3	0.7	0.8	21.3	20.9	44.7	184	179
59 Orchardgrass hay	14.2	85.2	6.9	2.6	30.9	38.6	6.8	3.5	1.2	18.2	20.5	45.2	190	181
60 Prairie hay western good quality	9.3	90.7	5.7	2.3	30.4	44.9	7.4	2.1	0.9	19.5	26.0	49.6	207	198
61 Red top hay	9.3	90.7	8.5	3.4	26.8	47.7	4.3	5.3	1.8	16.3	30.1	55.7	237	223
62 Sorghum fodder sweet dry	11.2	88.8	6.2	2.4	25.0	48.1	7.1	3.3	1.5	15.3	30.3	52.4	220	210
63 Soybean hay good	12.0	88.0	14.4	3.3	27.5	35.8	7.0	9.6	1.5	12.7	23.3	49.0	218	196
64 Sudan grass hay	10.7	89.3	8.8	1.6	27.9	42.9	8.1	4.3	0.8	17.9	24.5	48.5	206	194

/1/ Quantity ingested minus quantity in feces i.e. disappears from alimentary canal. Values are for ruminants and horses except as otherwise specified. /2/ Obtained by multiplying total nitrogen by a factor usually 6.25 /3/ Ether extract of finely ground feedstuff material /4/ Includes fiber (cellulose, lignin) and N-free extract (remainder of carbohydrate organic acids) /5/ "Total digestible nutrients" (TDN) as commonly calculated 1 x col. I + 2.25 x col. J + 1 x col. K + 1 x col. L. /6/ Feed calories minus fecal calories i.e. virtually absorbed calories before subtraction of urinary loss. Factors used are: protein (col. I) x 5.65; fat (col. J) x 9.3; carbohydrate (col. K, L) x 4.1. Where data on individual digested(ible) nutrients (col. I-L) are not available feed calories are calculated as TDN x 4.38 (B. H. Schneider) /7/ Net physiological Calories available for heat activity and growth. Metabolizable energy bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane), energy lost in feces and energy lost in urine. Factor used is: TDN (col. M) x 4.0 Another factor proposed for use with TDN is 3.6 (H. H. Mitchell)

PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN (Concluded)

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition, see page 13 ff

Constituents / Feedstuff	Water	Dry Matter	Crude Protein[2]	Crude Fat[3]	Total Carbohydrate[4]: Crude Fiber	Total Carbohydrate[4]: N-Free Extract	Ash	Digestible Protein	Digestible Fat	Digestible Total Carbohydrate: Fiber	Digestible Total Carbohydrate: N-Free Extract	Total Digestible Nutrients[5]	Digestible Energy[6]	Metabolizable Energy[7]
	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
[illegible]	7 8	92.2	13 8	1 6	4.7	33 3	13 8	11 9	0 5	[illegible]	3 3	7 7	[illegible]	[illegible]
[illegible]	1.	89 0	6 5	2 4	30 2	45 0	4 9	2 9	1 1	16 9	5 5	45 7	73	134
[illegible]	14.8	85.2	18 7	1 8	22 2	34 7	7 8	14 4	0 9	13 4	3 3	33 5	36	3
[illegible]	9 6	90 4	6 1	1 8	6 1	50 0	6 4	3 3	0 7	[illegible]	31	46	134	1
[illegible]	5	92 5	3 9	1 5	36 9	41 9	8 3	0 3	0 6	19 2	17 7	44 6	5	
Silages														
[illegible]	66 5	33 5	6.6	1 3	10 1	12 4	3 1	4.7	0 8	5 4	6 3	70 1	70	40
Alfalfa, [illegible]	65 7	34.3	5 7	1 1	11 0	13 8	2 8	3 9	0 7	5 8	8 8	0.0	89	40
Alfalfa, [illegible]	64.0	36 0	6 0	1 4	11 7	13 7	3 2	4.1	0 9	6.4	8 5	71 3	94	45
Alfalfa, [illegible] wilted	73 2	26 8	4.1	0 9	8.2	11.2	2 4	2 7	0 5	3 9	7 6	13 4	67	62
Alfalfa-[illegible] wilted	68 4	31 6	3 8	0 6	3 9	10.8	12 5	2 6	0 2	3 2	8 6	14.9	65	60
Beet top sugar	72 6	27 4	2 2	0 8	6.7	16.1	1 6	1 2	0 5	4 4	11 1	18 1	75	72
Corn, [illegible] well matured														
76 Corn and soybeans well matured 30%	71 7	28 3	3 2	1 2	7 3	14.2	2 4	2 0	1 0	4 5	10 9	19 7	4	79
soybeans	78 6	21 4	3 3	0 7	5 6	9 3	2 5	1 9	0 4	2 9	6 8	12 5	54	80
77 Cowpea	66 7	33 3	5 2	1 3	6.8	14.2	3 8	2 9	0 7	6 0	8 7	19 1	63	76
78 Grass silage large proportion legumes	71 0	29 0	3 0	0 9	8 9	14 2	2 0	1 6	0.6	5 9	9 2	18 0	77	72
wilted	74.7	25.3	1 6	0.8	6 9	14 4	1 6	0.8	0.5	3 9	9 4	13 2	64	61
79 Grass silage small proportion legumes wilted slightly molasses added	71 0	29 0	6 3	1 0	9 1	9 7	2 9	4 9	0 6	3 7	6 7	17 1	76	65
80 Sorghum sweet														
81 Sweetclover														

/1/ Quantity ingested minus quantity in feces i e disappears from alimentary canal Values are for ruminants and horses except as otherwise specified /2/ Obtained by multiplying total nitrogen by a factor usually 6 25 /3/Ether extract of finely ground feedstuff material /4/ Includes fiber (cellulose, lignin) and N free extract (remainder of carbohydrate organic acids) /5/ Total digestible nutrients (TDN) as commonly calculated 1 x col I + 2 25 x col J + 1 x col. K + 1 x col. L./6/Feed calories minus fecal calories i e , virtually absorbed calories before subtraction of urinary loss Factors used are: protein (col I) x 5 65; fat (col J) x 9 3; carbohydrate (col K, L) x 4 1. Where data on individual digested(ible) nutrients (col I L) are not available feed calories are calculated as TDN x 4 38 (B. K. Schneider) /7/ Net physiological Calories available for heat activity and growth. Metabolizable energy bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane) energy lost in feces and energy lost in urine Factor used is: TDN (col M) x 4 0 Another factor proposed for use with TDN is 3 6(H H Mitchell)

77 MINERAL AND VITAMIN COMPOSITION FEEDSTUFFS OF PLANT ORIGIN

Values are milligrams or grams per 100 grams of feedstuff as fed.

	Feedstuff / Constituents	Minerals					Vitamins				
		Calcium	Copper	Iron	Manganese	Phosphorus	Vitamin A as β-carotene[1]	Niacin	Pantothenic Acid	Riboflavine	Thiamine
		g/100g	mg/100g	mg/100g[2]	mg/100g	g/100g	mg/100g	mg/100g[2]	mg/100g	mg/100g	mg/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Concentrates										
1	Alfalfa meal dehydrated,17% protein	1.70	0.68	55	3.30	0.22	7.92	1.91	2.71	1.61	0.33
2	Alfalfa meal dehydrated,20% protein	1.66	1.56	59	6.29	0.31	13.2	3.81	4.07	1.63	0.68
3	Alfalfa meal,sun-cured,17% protein						5.28			1.94	
4	Barley excluding Pacific coast	0.09	1.12	4.9	1.63	0.47		5.31	0.81	0.18	0.37
5	Barley Pacific coast	0.06	1.12	6.8	1.72	0.41		4.41	0.73	0.13	0.40
6	Beet pulp molasses dried	0.62	1.3	26	3.9	0.09		1.9	1.2	0.1	0.02
7	Brewers dried yeast	0.11	3.32	13.8	0.53	1.52		47	10.81	3.08	9.47
8	Brewers grains dried,25% protein	0.25	2.4	2.8	4.3	0.49		4.1	1.2	0.1	0.04
9	Citrus pulp dried	2.06	0.86	15.0	0.44	0.15	0.02	2.11	1.32	0.22	0.13
10	Corn & cob meal (corn ears ground)					0.22					
11	Corn dent,yellow	0.02	0.20	2.0	0.51	0.27	0.29	2.16	0.57	0.11	0.37
12	Corn gluten feed 25% protein	0.41	4.58	42	2.25	0.82	1.3	6.65	1.72	0.18	0.007
13	Corn gluten meal 41% prot in	0.20	2.88	47	0.97	0.41	2.2	5.46	0.84	0.15	0.02
14	Cottonseed hulls	0.14				0.07				0.37	
15	Cottonseed meal,41% protein	0.18	1.69	7.6	2.84	1.14		2.86	0.97	0.55	0.39
16	Distillers dried corn grains	0.11	4.49	24.0	3.28	0.52		4.65	1.17	0.35	0.24
17	Distillers dried corn grains with solubles	0.16			4.01	0.74		7.99	1.14	0.75	0.46
18	Distillers dried solubles	0.35	7.99	50	10.00	1.40	0.2	11.96	1.96	1.15	0.59
19	Hominy feed white 5% fat	0.05	2.18	3.9	1.81	1.03		5.52	0.68	0.22	1.30
20	Linseed oil meal 35% protein old process	0.44	2.59	24.0	4.21	0.94		4.16	1.65	0.42	0.86
21	Molasses cane	0.74				0.08		4.60	3.94	0.24	0.09
22	Oats excluding Pacific coast	0.09	0.53	8.0	4.23	0.43		1.81	1.50	0.09	0.64
23	Oats,Pacifi coast										
24	Peas field seed	0.17				0.51		3.79	1.01	0.18	3.97
25	Rice bran	0.08			15.61	1.36		28	2.27	0.31	2.27
26	Rice grain brown		0.26	1.0	2.03	0.25		3.77		0.07	0.24
27	Rice polish	0.04				1.10		73	1.21	0.20	1.94
28	Rye grain	0.01	0.75	8.0	8.14	0.33		1.56	0.93	0.15	0.44
29	Sorghum,milo	0.04	1.72	5.3	1.30	0.27		2.68	1.10	0.09	0.40
30	Soybean grain	0.27	1.69	10.0	2.62	0.62		2.20	1.56	0.26	1.10
31	Soybean oil meal,41% protein	0.26	2.44	17.0	2.71	0.59				0.55	
32	Soybean oil meal,44% protein	0.30	1.70	15.0	3.08	0.66		3.67	1.34	0.44	0.18
33	Soybean oil meal solvent extract	0.29	1.50	10.0	3.04	0.63		3.77	1.37	0.31	0.11
34	Wheat hard red winter	0.05	0.44	5.3	3.96	0.41		5.31	1.39	0.11	0.51
35	Wheat soft Pacific coast		0.97	6.9	6.10	0.29		5.90	1.15	0.11	0.48
36	Wheat bran	0.14	1.08	16.2	12.33	1.30		13.99	2.99	0.31	0.86
37	Wheat flour middlings	0.07	0.46	2.2	8.59	0.65		9.74	0.99	0.18	1.32
38	Wheat screenings										
39	Wheat standard middlings	0.14	2.16	9.0	11.80	0.78		9.73	2.05	0.18	1.28
	Dry Roughages										
40	Alfalfa hay	1.47	0.81	25	4.51	0.24	2.51	3.83	1.78	1.36	0.29
41	Alfalfa hay dehydrated	1.38				0.25	9.55	1.47	3.83	1.47	0.44
42	Alfalfa leaf meal good	1.69			6.07	0.25	6.60	1.58	2.77	1.58	0.44
43	Bluegrass hay Kentucky	0.46	0.90	25	7.65	0.32			0.99		
44	Brome hay smooth										
45	Bromegrass hay	0.20			3.30	0.28		3.74			

/1/ 0.0006 mg β-carotene = 1 I.U vitamin A./2/Values of 25 and above are rounded to the nearest whole number

77 MINERAL AND VITAMIN COMPOSITION: FEEDSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams or grams per 100 grams of feedstuff as fed

	Feedstuff (Constituents)	Minerals					Vitamins				
		Calcium	Copper	Iron	Manganese	Phosphorus	Vitamin A as β-carotene[1]	Niacin	Pantothenic Acid	Riboflavine	Thiamine
		g/100g	mg/100g	mg/100g	mg/100g	g/100g	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Dry Roughages (Concluded)										
46	Clover hay alsike	1 15	0 53	40	10.38	0 23	10 4				
47	Clover hay crimson	1 23			21 98	0.24					
48	Clover hay Ladino	1 32		99	15 97	0 29					
49	Clover hay red	1 35	0 88	27	10.65	0 19	1 89	3 72	0 99	1 56	0 19
50	Clover & mixed grass hay high in clover	0 90	0 70	22 0	9.26	0.19	0 70				
51	Clover & Timothy hay 30-50% clover	0 68	0 62	19 0	8 58	0.20					
52	Corn cobs ground					0 02					
53	Corn fodder medium in water	0.21				0 14	0 39				
54	Cowpea hay	1 37		82		0.29					
55	Grass hay,mixed	0 48		56		0 21					
56	Lespedeza hay annual in bloom	1 02		25	13 47	0 18					
57	Oat hay	0.21		49	8 05	0 19					
58	Oat straw	0 19	0.99	18 0	2 97	0 10					
59	Orchardgrass hay	0 19				0 17					
60	Prairie hay western,good quality	0.36				0 18	2 05				
61	Red top,hay	0 38	0.35	11.0	2 06	0.23					
62	Sorghum fodder sweet dry	0 34			11.59	0 12	0.24				
63	Soybean hay,good	1 35				0 23	2 99				
64	Sudan grass hay	0.36		13 0	8 16	0.26	8.2				
65	Sweetclover hay	1 25	0 90	12 0	10 69	0.23					
66	Timothy hay	0.23				0.20	1.17	3 41		0 90	0.13
67	Vetch hay common	1 13	0.88	28	4 7	0 32					
68	Wheat hay	0.14				0 18					
69	Wheat straw	0.21	0 29	16 0	5 08	0 07					
	Silages										
70	Alfalfa prebloom										
71	Alfalfa in bloom										
72	Alfalfa slightly wilted	0 51	0 33	11 0	1 87	0 12	3 28				
73	Alfalfa-molasses not wilted	0 41				0 08	3 19				
74	Beet top sugar	0 31				0 07	1 12				
75	Corn dent well matured	0 10	0 13	3 0	1.94	0 06	1.41	1.25			
76	Corn & soybeans well matured 30% soybeans	0 20				0 08					
77	Cowpea	0.48		29		0.10					
78	Grass silage large proportion legumes wilted						5.35				
79	Grass silage,small proportion legumes wilted slightly molasses added					0.07					
80	Sorghum,sweet	0 08			3.3	0 04	0 59				
81	Sweetclover										

/1/ 0 0006 mg β-carotene=1 I U vitamin A. /2/ Values of 25 and above are rounded to the nearest whol number

Nutrients are especially sensitive to the reaction (pH) of the solvent and to exposure to air light and heat Unless otherwise stated, reference is made to the properties of the nutrient in aqueous solution Where no footnote is given the stability of the nutrient is estimated on the basis of its chemical composition or other well known properties

S = Stable i e nutrient exhibits no appreciable breakdown under conditions specified in footnote L = Labile i e nutrient exhibits appreciable decomposition under conditions specified in footnote

	Nutrient	Hydrogen Ion Concentration			Oxygen, Atmospheric	Light	Heat	Loss in Ordinary Cooking[1]
		Neutral pH 7	Acid <pH 7	Alkaline >pH 7				%
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Vitamins							
1	A	S[2]			L[2]	L[3]	S[2]	10-30
2	Ascorbic acid	L[4]	S[4]	L[4]	L[4]	L[4]	L[4]	20-80
3	Biotin	S	S[5]	S[5]	S[6]	S[6]	S[5]	0-72
4	Choline	S	S[7]	S	L	S	S	
5	Cobalamin[8]	S[9]	S[9]	S[9]	L	L	S[9]	
6	D_2[10]	S[11]		L[12]	L[12 13]	L[13]	L	Appreciable
7	E	S	S[14]	S	L[14]	L[15]	S[14]	50[16]
8	Folic acid group[17]	L	L[18]	S[18 19]	L[19]	L[20]	S[18]	0-97
9	Inositol	S	S[21]	S	S	S	S[21]	0-95
10	K	S	S	L[22]	S	L	S	
11	Niacin[23]	S[24]	S[24]	S[24]	S	S	S[24]	0-72
12	Pantothenic acid	S[25]	L[25]	L[25]	S	S	L	0-44
13	Para-aminobenzoic acid	S[26]	S[27]	S[28]	L	S	S	
14	Pyridoxine group[29]	S[30]	S[30]	S[30]	S[31]	L[32]	S[30]	
15	Riboflavine	S[33]	S[34]	L[35]	S[34]	L[35 36]	S[33 35]	0-48

/1/ Nutrient lost expressed as percentage of quantity of nutrient present before cooking /2/ Stable in an inert atmosphere; loses biological activity if heated in presence of oxygen for 5 5 hours /3/ Destroyed by ultraviolet light (UV) /4/ Decomposes in light; decomposition accelerated by oxygen metal ions /5/ 50% loss if heated in 20% HCl to 120° C for 6 hours; 40-60% loss if heated in 1 N KOH to 120° C for 17 hours /6/ Stable to air O_2 and UV /7/ Stable when autoclaved in 3 N HCl for 2 hours /8/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /9/ Stable for 2 hours at room temperature in 0.1 N acid or alkali and in boiling water at pH 7 for 2 hours /10/ Calciferol /11/ Stable in dry propylene glycol more than three years when stored in amber bottles /12/ Some loss in alkaline feeds e g lime /13/ Activity lost in mixed feeds also under prolonged irradiation in presence of oxygen /14/ In absence of oxygen stable to heat up to 200° C and not affected by H_2SO_4 and HCl at 100° C /15/ Tocopherols stable to visible light but readily destroyed by UV /16/ Deep fat frying and baking result in appreciable destruction. /17/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U L. casei factor Norite eluate factor /18/ No destruction at pH 6 8 and 100°C for 30 minutes; 70-100% loss on autoclaving in pH range 4-12 /19/ Aeration at pH 10 causes partial inactivation /20/ Rapidly inactivated by light /21/ Stable to refluxing with 10% HCl for 6 hours to alkali and to a variety of chemical agents /22/ Sensitive to alkali /23/ Nicotinamide; nicotinic acid The nicotinamide is partially hydrolyzed by alkali and acid but the product nicotinic acid having the same vitamin activity as nicotinamide retains its biological activity /24/ Autoclaving with water acid or alkali used in extracting nicotinamide from mixture with other food substances /25/ Maximum stability over pH range 5 5-7 0; rapidly hydrolyzed under more acidic or alkaline conditions /26/ Maximum yields obtained by autoclaving aqueous solutions /27/ Only 1% destruction on autoclaving solutions in 6 N H_2SO_4 for 60 minutes /28/ Probably stable to autoclaving with 1 N NaOH but long treatment with alkali results in destruction /29/ Includes pyridoxine pyridoxal pyridoxamine /30/ Pyridoxine not destroyed by heating with 5 N acid or alkali at 100° C, or autoclaving in acid or alkali; pyridoxal and pyridoxamine stable in hot acid, but pyridoxal partially decomposed by hot alkali /31/ Oxidized only by such strong agents as hot HNO_3 H_2O_2 /32/ Rapidly destroyed by UV in neutral or alkaline solution /33/ Stable in neutral or acid solutions /34/ 1.2% decomposed per month at pH 5 0 at 27° C /35/ Destruction rate in presence of light increases as pH and temperature increase /36/ 50% of the riboflavine of milk destroyed when exposed to sunlight for 2 hours

78 STABILITY AND LABILITY OF NUTRIENTS (Concluded)

Nutrients are especially sensitive to the reaction (pH) of the solvent and to exposure to air light and heat Unless otherwise stated reference is made to the properties of the nutrient in aqueous solution Where no footnote is given, the stability of the nutrient is estimated on the basis of its chemical composition or other well known properties

S = Stable i e nutrient exhibits no appreciable breakdown under conditions specified in footnote L = Labile i e nutrient exhibits appreciable decomposition under conditions specified in footnote

	Nutrient	Hydrogen Ion Concentration			Oxygen Atmospheric	Light	Heat	Loss in Ordinary Cooking[1]
		Neutral	Acid	Alkaline				
		pH 7	< pH 7	> pH 7				%
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Vitamins (concluded)							
16	Thiamine	L[37]	S[38]	L[39]	L[40]	S	S[38, 41]; L[37, 39]	25-45
	Unsaturated fatty acids							
17	Linoleic linolenic Arachidonic	S	S	L[42]	L[43]	L[43]	S[42, 44]	<10[44]
	Amino acids							
18	Isoleucine	S	S	S[45]	S	S	S	Very small
19	Leucine	S	S	S[45]	S	S	S	Very small
20	Lysine	S	S	S[45]	S	S	S	Very small
21	Methionine	S	S	S[45]	S	S	S	Very small
22	Phenylalanine	S	S	S[45]	S	L[46]	S	Very small
23	Threonine	S	S[47]	L[45]	S	S	S	Very small
24	Tryptophan	S	L[47]	S[45]	S	L[46]	S	Very small
25	Valine	S	S	S[45]	S	S	S	Very small
26	Inorganic salts	S	S	S	L[48]	S	S	Very small

/37/ 96.4% destroyed at 100°C at pH 7 in 3 hours /38/ No destruction in 1% HCl in 7 hours at 100° C /39/ 100% destroyed in 15 minutes at pH 9 at 100°C /40/ Unstable in presence of air /41/ Heat stability a function of pH and nature of buffer /42/ Isomerization of double bonds occurs in 7 minutes in 20% KOH at 178°C although these vitagens appear to be less labile at lower temperatures /43/ Sensitive to light and air oxidation. /44/ Almost no destruction of multiple unsaturated fatty acids by heat unless in strongly alkaline solution (cf Fn 42) /45/ Most amino acids undergo racemization in alkaline solutions but they are otherwise stable /46/ Modified by UV /47/ Tryptophan completely destroyed by hot 20% HCl in 12 hours; threonine undergoes slight destruction Only partial destruction on refluxing with 2 5 N H_2SO_4 for 6 hours /48/ Oxidation of some inorganic salts of lower valence states to higher valence states when exposed to atmospheric oxygen i e ferrous to ferric iron

79 FOOD NUTRIENT LOSSES IN COOKING

Each value is the nutrient lost in cooking expressed as a percentage of the quantity of the same nutrient present in the uncooked edible portion of the food material. Values are roughly approximate only

	Food Type	Species	Method of Cooking	Minerals: Calcium	Minerals: Iron	Minerals: Phosphorus	Vitamins[1]: Vitamin A	Vitamins[1]: Ascorbic Acid	Vitamins[1]: Niacin	Vitamins[1]: Riboflavine	Vitamins[1]: Thiamine
				%	%	%	%	%	%	%	%
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Plant Food										
1	Cabbage[2]	Brussels sprouts, Cabbage	Boiling: retaining water					10	25	1	
2			discarding water					40	25	15	
3			Pressure saucepan					50			
4			Steaming					50	20	15	
5	Cereals	Rolled oat	Double boiler: 15 min.						03	03	0
6			30 min.						0	03	2
7			180 min.						03	03	8
8	Corn[2]	Corn	Boiling					55	15	10	20
9	Flowers and shoots[2]	Asparagus, Broccoli, Cauliflower	Boiling: retaining water				0	10	15		1
10			discarding water	20	5	15	0	50	25	35	40
11			Pressure saucepan					50			
12			Steaming				0	25	15	15	15
13	Leafy[2]	Kale, Spinach, Swiss chard and others	Boiling: retaining water					25	20	30	5
14			discarding water	20	5	15		50	25	50	30
15			Pressure saucepan					50			
16			Steaming					60	10	15	15
17	Legumes, fresh[2]	Beans, Peas	Boiling: retaining water					5	5	0	10
18			discarding water	0	1	5	15	40	20	20	20
19			Steaming				10	15	0	5	5
20	Potatoes[2]	Potato	Baking					25			
21			Boiled in jackets					0			
22			Boiling: retaining water						15		
23			discarding water	15	10	0		20	20	25	20
24			Mashed					50			
25			Pressure saucepan					50	0	5	5
26			Steaming					15			
27	Roots and bulbs[2]	Beet, Carrot, Onion, Parsnip, Turnip	Boiling: retaining water				5	10	15	15	
28			discarding water	1	5	0		65	35		
29			Pressure saucepan	25	5	15					
30			Steaming				5	50	40	0	25
31	Squash[2]	Squash	Steaming					55			50
	Animal Food										
32	Meats	Unspecified	Braising: retaining drippings						10	5	40
33			discarding drippings						55	25	55
34			Broiling: retaining drippings						5	10	25
35			discarding drippings						20	20	30
36			Roasting: retaining drippings						5	10	30
37			discarding drippings						20	15	40
38			Stewing: retaining water						0	0	50
39			discarding water						50	50	75
40	Fish	Unspecified	Frying						5	10	
41			Steaming						5	0	

/1/ Loss of water soluble vitamins increases in proportion to amount of cooking water used. /2/ Cooked immediately without standing after preparation

APPARENT DIGESTIBILITY AND ABSORBABILITY OF NUTRIENTS VERTEBRATES

Values are grams of protein fat or carbohydrate digested and virtually absorbed per 100 g of the nutrient ingested as part of the foodstuff or feedstuff listed The quantity apparently digested and virtually absorbed is taken as the quantity of the nutrient ingested minus the quantity of the same nutrient subsequently found in the feces Fecal "protein (= 6.25 x fecal N) includes amino acids other N compounds Fecal fat (ether extract) includes bacterial lipids also lipids excreted through intestinal wall Values for man are for the food as commonly prepared for ingestion Values are subject to marked change with variation in the diet High dietary cellulose content increases fecal losses of other nutrients

	Food- or Feedstuff	Man			Cattle				Horse				Chicken		
		Protein	Carbohydrate	Fat	Protein	Carbohydrate Fiber	Carbohydrate NFE[1]	Fat	Protein	Carbohydrate Fiber	Carbohydrate NFE[1]	Fat	Protein	Carbohydrate	Fat
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
1	Animal products[2]	97	98	95											
2	Bone meal												87	34	95
3	Buttermilk dried												69	71	95
4	Eggs	97	98	95											
5	Fats			95[3]											
6	Fish meal				76			97					75	55	83
7	Liver meal												65	45	91
8	Meat and fish	97		95											
9	Meat scrap												61	60	90
10	Milk milk products	97	98	95	96[4]		99[4]	100[4]	91[4]		90[4]	90[4]			
11	Milk skim dried				96[4]		100[4]	38[4]					75	66	57
12	Plant products[2]	85	97	90	70?	40?	76?	77?					76?	69?	80?
13	Concentrates														
14	Cereal grains seeds														
15	Barley				70	6	88	65	88	39	87	85	73	80	75
16	Corn gluten meal				86[5]	70[5]	88[5]	74[5]					81	57	55
17	Corn meal degermed	76	99	90											
18	Corn meal whole ground	60	96	90	63[6]	15[6]	88[6]	83[6]	69[6]	31[6] [7]	89[6]	59[6]	86	94	90
19	Cottonseed meal				81	57	80	92					70	56	97
20	Linseed oil meal old process				85	11[8]	78	93	84		55	35			
21	Macaroni spaghetti	86	98	90											
22	Oat meal rolled oats	76	98	90											
23	Oats whole grain				74	13	76	84	77	10	74	66	56	66	92

/1/ Nitrogen-free extract /2/ Variety not specified. /3/ Digestibility varies inversely with saturation and length of carbon chain and is less in infants than adults /4/ Refers to milk and animal of particular species /5/ Corn gluten feed. /6/ Corn grain. /7/ For explanation of the minus value see Fn 8 /8/ Some feedstuffs when ingested either (a) stimulate intestinal excretion of nutrients specifically nitrogen ("protein") or lipids or (b) decrease the digestibility of nutrients e g , fiber The negative percentage digestibility refers to this action. Ingestion of linseed oil meal causes more fiber to be lost in the feces than was originally contained in the quantity of oil meal ingested. The additional fiber thus lost comes from other roughages (whose digestibility is known) fed along with the oil meal.

80 APPARENT DIGESTIBILITY AND ABSORBABILITY OF NUTRIENTS VERTEBRATES (Concluded)

Values are grams of protein, fat or carbohydrate digested and virtually absorbed per 100 g of the nutrient ingested as part of the foodstuff or feedstuff listed. The quantity apparently digested and virtually absorbed is taken as the quantity of the nutrient ingested minus the quantity of the same nutrient subsequently found in the feces. Fecal protein (= 6.25 x fecal N) includes amino acids, other N compounds. Fecal fat (= ether extract) includes bacterial lipids, also lipids excreted through intestinal wall. Values for man are for the food as commonly prepared for ingestion. Values are subject to marked change with variation in the diet. High dietary cellulose content increases fecal losses of other nutrients.

	Food or Feedstuff	Man Protein	Man Carbohydrate	Man Fat	Cattle Protein	Cattle Carbohydrate Fiber	Cattle Carbohydrate NFE[1]	Cattle Fat	Horse Protein	Horse Carbohydrate Fiber	Horse Carbohydrate NFE[1]	Horse Fat	Chicken Protein	Chicken Carbohydrate[1]	Chicken Fat
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
	Cereal grains seeds (concluded)														
24	Peanut meal												74	51	91
25	Rice brown	75	98	90											
26	Rice white or polished	84	99	90											
27	Soybean oil meal				86	65	72	88					74	34	79
28	Wheat 97-100% extraction	79	90	90											
29	Wheat 85-93% extraction	85	94	90											
30	Wheat 70-74% extraction	89	98	90											
31	Wheat whole grain												93	95	96
32	Wheat bran				76	50	76	74	73	22	55	27	59	57	86
33	Wheat middlings												68	65	86
34	Fat			95				77							88
35	Fruit	85	90	90											
36	Potatoes	74	96	90					63	75	101	42			
37	Sugar		98						70	52	65	50			
38	Yeast								91		105		69	54	48
39	Roughages														
40	Green roughages														
41	Kentucky bluegrass				68	70	65	51							
42	Pasture grass mixed				75	74	77	42							
43	Silage corn				45	64	69	70							
44	Timothy				59	68	72	57							
45	Dried roughages														
46	Alfalfa hay				71	55	70	58	69	36	61	0			
47	Alfalfa meal												56	54	55
48	Clover hay				49	46	62	47	56	58	64	29			
49	Timothy hay				56	51	62	65	43	43	55	13			

Column heading: Apparent Quantity of Nutrient Digested and Absorbed

/1/ Nitrogen-free extract.

81 CALORIE VALUES OF NUTRIENTS

Each Calori value applies to 1 gram of th ingested nutrient -- prot i arbohydrat f t f orial pecified t head f lt colum The [illegible] tities and percentages except for the values in line I are subject to marked hange with vari tion in the [illegible] High dietary cellulose content increases fecal losses of othe nutrient

One Gram of Ingested Nutrient	Man: Calorie Value for Protein		Carbohydrate[1]		Fat		Monkey: Calorie Value for Protein		Carbohydrat	Fat	Cattle: Calorie Value for Protein	Carbohydrat		Fat	Chicken: Calorie Value for Protein	Carbohydrat	Fat
	From Plant	From Animal	From Plant	From Animal	From Plant	From Animal	From Plant	From Animal	Mostly Plant	Mostly Plan	From Plant	Plant Fiber[4]	Plant NFE[2]	From Plan			
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
1 Total energy content by bomb calorimeter[3]	5.65	5 65	4 15	3 90	9 30	9 40	5 65	5.65	4 1	9 3	5 65	4 [illegible]	4 [illegible]	[illegible]	5 [illegible]	4 [illegible]	[illegible]
2 Lost in rumen gases[6]												0 3	0 [illegible]				
3 Lost in feces[7]	0 89[8]	0 15[8]	0 15[9]	0 10[7]	0 [illegible][10]	0 [illegible][10]	0 61[11]	0 [illegible][12]	0	0	1 [illegible]	1 [illegible]	0 [illegible]	2 [illegible]	1 5[illegible][14]	[illegible][14]	[illegible][14]
4 Virtually absorbed[15]	4 80	5.50	4 00	3 80	8 [illegible]	8 [illegible]	5 01	5 09	[illegible]	[illegible]	4 1		1	5 2	4 33	[illegible]	[illegible]
5 Virtually absorbed as % of 1A	85	97	97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6 Virtually absorbed as % of 1A on average diet	9[illegible][16]		97[17]		9[illegible][18]		[illegible]				[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7 Lost in urine[21]	1 06[22]	1 21[22]	0	0	0	0	1 [illegible]	[illegible]	0	0	1 [illegible]	0	0	0	0 5[illegible]	0	0
8 Lost in urine as % of 4A	22	22					33	40			[illegible]				[illegible]		
9 Lost in urine as % of 4A on average diet	22[16]						[illegible]				[illegible]				[illegible]		
10 Metabolized for heat activity growth[26]	3 74	4 29	4 00	3 80	8 35	8 95	3 41	3 05	[illegible]	[illegible]	[illegible] 72	[illegible] 05	2 81	5 8[illegible]	3 46	3 6	7 [illegible]
11 Metabolized for heat activity growth[20] on average diet	4 08[16]		3 99[17]		8 90[18]		3 0[illegible]				[illegible] 71[illegible]		[illegible] 61[19,20]	5 82[20]	3 46	3 56	7 55
12 Metabolized (line 11) rounded off to:	4 0		4.0		9 0						2 7		2 6	5 8			

/1/ Carbohydrate of plant origin (except from potatoes white flour starch etc) is likely to include more or less of fiber" chiefly cellulose This carbohydrate has the same bomb calorimeter value as has starch but is poorly digested except by ruminants In these fermentation in the rumen breaks down complex carbohydrates to simpler forms (including organic acids) that are digestible or directly absorbable (see also Fn 6) / / NFE nitrogen free extract = hemicellulose starch sugar organic acids etc /3/ 1 gram of (chemically pure) nutrient pecified at top of column burned yields Calories as given. /4/ Mean of 7 96 for fat from roughage and 9 47 for fat from grain. /5/ Fat from grain. /6/ From f rmentation of fiber and NFE (Fn 2) in rumen of cattle A 550 kg cow may lose 4 000 Calories/day (400 liters of methane) /7/ Fecal nitrogen x 6 25 = protein Fecal fat (= ether extract) contains excreted lipids and fecal bacterial lipids /8/ Fecal protein 15% of ingested protein if of plant origin; 3% if of animal origin; 8% on average diet /9/ Fecal carbohydrate 5% of ingested carbohydrate if of plant origin; 2% if of animal origin; 3% on average diet The fecal loss is larger if plant carbohydrate includes much cellulose /10/ Fecal fat = 10% of ingested fat if of plant origin; 5% of ingested animal fat; 5% on average diet /11/ Fecal protein 10% of ingested protein. /12/ Lost in feces: 30% of protein from roughage and 25% of protein from concentrates Approximately 44% of dietary protein i from roughage 56% from concentrates /13/ Lost in feces: 49% of fat from roughage and 18% of fat from concentrates Approximately 50% of dietary fat is from roughages 50% from concentrates /14/ Consistent with digestibility coefficients of Fraps (ref 11) applied to a growing ration. /15/ Line 1 minus lines 2 and 3 /16/ Dietary protein U S A. 39% of plant 61% of animal origin. /17/ Dietary carbohydrate U S A. 95% of plant 5% of animal origin. /18/ Dietary fat U S A. 8% of plant 92% of animal origin. /19/ Assumed diet contains 27% of carbohydrate as fiber 73% as NFE. /20/ Maintenance ration for mature cow is usually 100% roughage Production ration usually 70-75% roughage [illegible]% concentrates /21/ Chiefly urea for man uric acid for chicken. /22/ Calculated from 1 25 urinary Calories per gram of virtually absorbed protein by 1 25 x 58 and 1.25 x 50 /23/ Based on urea only Loss calculated as 2.29 and 3 31 if based on total urinary N /24/ All Calori s in urine attributed to protein metabolites /25/ Assumed dietary protein 10% of plant 90% of animal origin. /26/ Net physiological energy per gram of ingested nutrient

82 ACCUMULATIVE EFFICIENCY OF FEED UTILIZATION FOR GROWTH VERTEBRATES

Unless otherwise indicated, values are grams gain in body weight per gram of feed consumed (or pounds gain per pound of feed consumed), calculated by dividing total gain in weight from birth weight to per cent of mature weight stated, by total weight of the feed consumed, including natural moisture content since birth

	Species	At Percent of Mature Weight: 10% Male	10% Female	25% Male	25% Female	50% Male	50% Female	90% Male	90% Female
		g of gain/	g of feed	g of gain/	g of feed	g of gain/	g of feed	g of gain/	g of feed
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
1	Cattle, dairy, large	0 45	0 54	0 26	0 31	0 17	0 16		0 05
2	Cattle, dairy, small	0 39	0 44	0 33	0 27	0 16	0 20		0 07
3	Cattle, beef	0 62	0 61	0 30	0 25	0 15	0 14		
4	Rat, Sprague-Dawley	0 41		0 31		0 15			
5	Rat, Wistar	0 44		0 34		0 14			
6	Swine[1]	♂♀ 0 37[2]		♂♀ 0 27[3]		♂♀ 0 21[4]			
7	Chicken, white leghorn	0 45[5]	0 45[6]	0 41	0 4	0 33	0 3		0 14
8	Chicken, heavy breeds	0 53[7]	0 54	0 45	0 43	0 35	0 33		0 19
9	Turkey, Beltsville small	♂♀ 46		♂♀ 42		♂♀ 34		♂♀ 23	
10	Turkey, bronze broad breasted	♂♀ 46		♂♀ 42		♂♀ 34			

/1/ Based on 56 day weaning weight and feed consumption figures calculated for three periods: 56-98 days, 98-140 days, and 140-180 days /2/ Extrapolated Calculated on basis of mature weight of 600 pounds 0 39 (extrapolated), calculated on basis of mature weight of 500 pounds /3/ Calculated on basis of mature weight of 600 pounds 0 29, calculated on basis of mature weight of 500 pounds /4/ Extrapolated Calculated on basis of mature weight of 600 pounds 0 22, calculated on basis of mature weight of 500 pounds /5/ Value also reported, 0 48 /6/ Value also reported, 0 45 /7/ Value also reported, 0 44

83 ABSORPTION RETENTION EXCRETION OF NORMAL TISSUE CATIONOGENS MAMMALS

	Cationogen	Absorption[1]			Retention[2]				Excretion Via[2]		
		Mostly Absorbed	Partly Absorbed	Mostly Unabsorbed[2]	Bone, etc	In Organs[3]	General Tissues	Extracellular	Urine	Bile	Intestine[4]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Aluminum[5]			+		+			+	+	
2	Calcium		+		++		+		+	+	+
3	Cesium[5,6]	+				+	+		+	+	+
4	Cobalt[6,7]		+			+			++	+	+
5	Copper[7]		+			+			++	+	
6	Iron[6,7]			+		+					+
7	Lithium[5]	+				+	+		++		+
8	Magnesium		+		+	+	+		++	+	
9	Manganese[7]			+	+	++	+			+	+
10	Nickel[5,7]		+			++	+		++		
11	Potassium	+					+		+	+	+
12	Rubidium[5]	+				+	+		+	+	
13	Scandium[5]			+[8]	+		+		+		
14	Sodium	+			+	+	+		++	+	+
15	Tin[5,7]		+			+	+		++		+
16	Titanium[5]			+[8]		+					
17	Zinc[6]			+		+	+		+	+	++

/1/ After oral administration. Mostly absorbed =>70% partly absorbed = 5-70%; mostly unabsorbed =>5% Extent of absorption may depend on the amount offered; it is assumed that the various ions are offered in the form of simple soluble compounds or metallic oxides /2/ Due to inadequate absorption after oral administration data on retention and excretion of poorly absorbed elements are from parenteral administration. /3/ Kidney liver pancreas spleen etc /4/ Other than in the bile or by route not definitely established. /5/ Not commonly thought of as normal tissue cationogen but is present in trace quantities as a result of occurrence in small amounts in animal foods /6/ Data obtained in part from studies using radioactive isotopes /7/ Valence of two /8/ Probably in view of position in the periodic table and/or water solubility

84 ABSORPTION RETENTION EXCRETION OF FOREIGN CATIONOGENS MAMMALS

	Cationogen[1]	Absorption[2] Mostly Absorbed	Absorption[2] Partly Absorbed	Absorption[2] Mostly Unabsorbed[5]	Retention[3] Bone etc	Retention[3] In Organs[4]	Retention[3] General Tissues	Excretion Via[3] Expired Air	Excretion Via[3] Urine	Excretion Via[3] Bile	Excretion Via[3] Intestine[5]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Americium			+	++	+	+		+		++
2	Antimony[6]		+			++	+		++		+
3	Arsenic[6]		+		+	+	++	Tr	++		+
4	Barium		+		+				Tr		++
5	Beryllium			+	++	+	+		+		+
6	Bismuth[6]			+	++	++	+		++		+
7	Cadmium[7]			+		+			+		++
8	Cerium			+	+	+					+
9	Chromium			+[8]	++	+			+		
10	Curium			+[8]	++	++	+		+		++
11	Francium	+[8]				+	+		+[8]		
12	Gallium			+	++	+			++		+
13	Germanium[7]	+			+	+	+		++		+
14	Gold[7]			+		+			++		+
15	Lanthanum			+	+	+			+		
16	Lead[8]		+		++	++	+		+	+	+
17	Mercury[7] [9]		+			++	+		++	+	+
18	Neodymium[7]			+[8]	+		+				+
19	Neptunium			+	+						
20	Niobium			+			+		+		

	Cationogen[1]	Absorption[2] Mostly Absorbed	Absorption[2] Partly Absorbed	Absorption[2] Mostly Unabsorbed[5]	Retention[3] Bone etc	Retention[3] In Organs[4]	Retention[3] General Tissues	Excretion Via[3] Expired Air	Excretion Via[3] Urine	Excretion Via[3] Bile	Excretion Via[3] Intestine[5]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
21	Palladium[7]			+[8]	+	+	+		++		+
22	Platinum[7]			+[8]		+			++		+
23	Plutonium			+	++	+	+		+		++
24	Polonium			+[8]	++	++	+		+		++
25	Praesodymium			+	+	+					+
26	Promethium			+	+	+					+
27	Protactinium			+[8]	+						
28	Radium		+		+	+			+		++
29	Radium D		+[8]						+		+
30	Ruthenium			+		+					
31	Samarium[7]			+		+					
32	Selenium[7] [10]	+				++	+	+	+		
33	Silver			+	+	+	+		Tr	++	
34	Strontium		+		+				++		+
35	Tellurium[10]		+			+		+	+	+	
36	Thallium[7,11]	+				+	+		++		+
37	Thorium			+	+	++			Tr		+
38	Uranium[7,12]		+		+	+[13]			+		
39	Yttrium			+	+	+			++		+
40	Zirconium			+	+						

/1/ Unless otherwise indicated all cationogens used were radioactive or the data were obtained at least in part from studies using radioactive isotopes /2/ After oral administration. Mostly absorbed =>70%; partly absorbed = 5-70%; mostly unabsorbed =<5% Extent of absorption may depend on the amount offered; it is assumed that the various ions are offered in the form of simple soluble compounds or metallic oxides /3/ Due to inadequate absorption after oral administration, data on retention and excretion of poorly absorbed elements are from parenteral administration /4/ Kidney, liver, pancreas spleen, etc /5/Other than in the bile, or by route not definitely established. /6/ Valence of three /7/ Studies made on normally occurring isotopes /8/ Probably in view of position in the periodic table and/or water solubility /9/ Valence of two /10/ Valence of four /11/ Valence of one /12/ Valence of six /13/ Retention in liver and kidney for only short periods

85 ABSORPTION RETENTION EXCRETION OF NORMAL TISSUE ANIONOGENS: MAMMALS

	Anionogen	Absorption[1]			Retention				Excretion Via			
		Mostly Absorbed	Partly Absorbed	Mostly Unabsorbed	Bone, etc	In Organs[2]	General Tissues	Extracellular	Expired Air	Urine	Bile	Intestine[3]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
1	Bicarbonate	+			+	+	+		+	+	+	+
2	Chloride	+			+	+	+	+		++	+	+
3	Fluoride	+			+			+		++		
4	Iodide	+				+[4]	+	+		++	+	
5	Molybdate		+		+	+				++		+
6	Phosphate		+		++	+	+			++	+	+
7	Silicate[5]		+			+				+		+
8	Vanadate	+				+				++		+

/1/ After oral administration Mostly absorbed =>70%; partly absorbed = 5-70%; mostly unabsorbed =<5% Extent of absorption may depend on the amount offered It is assumed that the various ions are offered in the form of simple soluble compounds, or metallic oxides /2/ Kidney, liver, pancreas, spleen, etc /3/ Other than in the bile, or by route not definitely established. /4/ Highly concentrated in thyroid /5/ Data obtained in part from studies using radioactive isotopes

86 ABSORPTION RETENTION EXCRETION OF FOREIGN ANIONOGENS: MAMMALS

	Anionogen	Absorption[1]			Retention[2]				Excretion Via[2]		
		Mostly Absorbed	Partly Absorbed	Mostly Unabsorbed[2]	Bone, etc	In Organs[3]	General Tissues	Extracellular	Urine	Bile	Intestine[4]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Bromide	+				+	+	+	++	+	+
2	Chromate	+				+			++		+
3	Nitrate	+					+		++	+	+
4	Perrhenate			+[5]		+			+		
5	Thiocyanate	+				+	+	+	++	+	+
6	Tungstate		+		+	+			+		

/1/ After oral administration Mostly absorbed =>70%; partly absorbed = 5-70%; mostly unabsorbed =<5% Extent of absorption may depend on the amount offered it is assumed that the various ions are offered in the form of simple soluble compounds, or metallic oxides /2/ Due to inadequate absorption after oral administration, data on retention and excretion of poorly absorbed anionogens are from parenteral administration /3/ Kidney, liver, pancreas, spleen,etc /4/ Other than in the bile, or by route not definitely established /5/ Probably, in view of position in the periodic table and/or water solubility

87 CHEMICAL ELEMENTS FUNCTIONS ANIMALS

The functions listed in the table require the specific elements noted. In addition carbon hydrogen nitrogen oxygen phosphorus and sulfur are required for the functions of synthesis of structural proteins carbohydrates fats and other organic compounds, and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Bromine	Traces in many foods Probably completely absorbed from gastrointestinal tract	Same as chloride in mammals In Tyrian Purple (=brominated indigo) derived from viscera of marine gastropod, (Purpura aperta); in dibromo tyrosine in protein gorgonin from coral (Primnoa lepadifera).	Not known.	Mainly in urine
Calcium	Almost entirely as salts of inorganic or organic acids Partial absorption from gastrointestinal tract Absorption aided by vitamin D and low pH	Insoluble calcium phosphate complex in bones teeth in vertebrates In exoskeleton of numerous invertebrates as calcium carbonate Minute concentrations as soluble salts in body fluids all species As calcium carbonate in shell of certain eggs.	Component of supporting structure in higher forms many lower forms Vital electrolyte of cell and extracellular fluid Protective shell of eggs	In urine feces in varying portions
Chlorine	As for sodium.	Distribution similar to that of sodium but in general milliequivalent concentrations are lower Chief anion of gastric juice Also present in all other gastrointestinal secretions and all extracellular fluids.	Although principal anion of extracellular fluid function is unknown. Variation in Cl concentration appears to be better tolerated than in Na and most other electrolytes	Chiefly in urine Variable amount in sweat
Cobalt	Trace constituent of many foods Absorbed from gastrointestinal tract	Trace distribution in many tissues particularly glands and visceral organs e g. liver	Component of vitamin B_{12} (Cobalamin) required by some species from lowest to highest forms Cobalt deficiency occurs in ruminants as Pine disease salt sickness bush sickness coast disease Cobalt enhances activity of certain peptidases.	In urine and feces
Copper	Minute amounts in food as copper protein complexes Poorly absorbed from intestine	Higher concentrations in invertebrates than in vertebrates Highest concentrations in hepatopancreas and gonads of Mollusca; lowest concentration in muscle High concentration in gut of insects Present in turacin (red pigment of feathers of turaco bird) Injected Cu accumulates in liver kidney Liver is principal site of storage	Erythropoiesis Myelinization of central nervous system. Maintenance of mammalian pigmentation. Trace quantities essential for hemoglobin and possibly iron-porphyrin-protein enzyme synthesis. Constituent of several enzymes present in animal tissues (polyphenol oxidase tyrosinase laccase catechol oxidase and ascorbic acid oxidase). Component of hemocyanin, respiratory pigment of numerous marine animals; component (cont d on next page)	Most of orally administered copper appears in feces due to poor absorption. Parenterally administered Cu is slowly excreted mainly in feces less in urine

87 CHEMICAL ELEMENTS, FUNCTIONS ANIMALS (Continued)

The functions listed in the table require the specific elements noted. In addition carbon hydrogen nitrogen oxygen phosphorus and sulfur are required for the functions of synthesis of structural proteins carbohydrates fats and other organic compounds, and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Copper (concluded)			of hepatocuprein hemocuprein-protein complexes found in liver blood of certain mammals Nutritional deficiency disease occurs in cattle sheep with inadequate intake or with increased intakes of molybdenum. Molybdenum and copper are mutually antagonistic in ruminant metabolism.	
Fluorine	Traces in various foods significant quantities in water in certain areas	Present in bones teeth. High concentration of 0 6 to 1 6 per cent F in bones of sea animals.	Diminishes solubility of bones and teeth in weakly acid solutions Decreases caries incidence.	Primarily in urine
Iodine	Trace amounts in various foods mostly as iodide or as component of organic compounds Amount in food related to I content of soil. Absorbed from intestine and in lower forms through cell membranes.	Principally in thyroid of vertebrates Component of thyroxin diiodotyrosine and thyroglobulin. Trace amounts in other tissues Relatively more iodide in marine fish and other marine animals	Minute intake essential for growth and for prevention of goiter	Mainly in urine
Iron	Mainly as ferrous compounds from gastrointestinal tract More absorption with iron deficiency states	In blood hemoglobin muscle hemoglobin cytochrome of all cells Stored in liver and spleen as ferritin (iron phosphoprotein)	Respiratory pigments of higher and lower forms (Platyhelminthes contain hemoglobin.) Cytochrome is present in practically all cells	Only traces in excreta. Loss by excretion not more than 1 mg/day except in presence of hemorrhage Iron in feces is primarily dietary unabsorbed iron.
Magnesium	Widely distributed in foods Ingested as salt of inorganic or organic acid. Absorbed from intestine	Minute amounts in plasma and extracellular water Large amounts in intracellular fluid.	Essential electrolyte Low concentrations increase cell irritability Required for activity of several animal enzymes.	Urine and feces
Manganese	Traces present in most plant and animal foods Poorly absorbed from gastrointestinal tract	Particularly in liver pancreas and hair Also in all other tissues Blood pigment of shell fish (Pinna squamosa) contains Mn rather than Fe or Cu.	Component of enzyme arginase Enhances effect of certain proteinases Necessary for growth of young animals (rabbits rats) Also required for proper reproduction in many adult forms Required for fertility of hen s eggs Needed to prevent perosis in chicks	Mainly in feces; traces in urine

The functions listed in the table require the specific elements noted In addition carbon hydrogen nitrogen oxygen phosphorus and sulfur are required for the functions of synthesis of structural proteins carbohydrates fats and other organic compounds and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Phosphorus	Occurs as phosphate in most foods Absorbed from gastrointestinal tract in higher forms Absorbed through cell membranes in lower forms	Large quantities as phosphate complex of calcium in bone of vertebrates Component of phospholipids (nerve and other tissues) phosphocreatine or phosphoarginine (muscle); as inorganic PO_4 in cell extracellular fluid; as nucleoprotein in all tissues; and as adenosine triphosphate (ATP) in variety of cells of higher and lower species Intracellular inorganic phosphate low relative to phosphate esters.	Important structural component of bone Component of high energy P compounds (ATP phosphocreatine phosphoarginine acetyl phosphate) Combines with intermediates in carbohydrate metabolism Buffer in urine Constituent of nucleoprotein. Component of phospholipids (intermediates in lipid metabolism)	Excreted in urine and feces
Potassium	Ingested as inorganic salt in variety of foods Absorbed from intestine Absorbed through gills and cell membranes in many lower marine forms	Principal cation of intracellular wat r Small amount in extracellular water	Essential cation of intracellular fluid.	Almost entirely in urine Minute amounts in feces and sweat
Silicon	Absorbed from intestine Inhaled particles deposit in lungs and give rise to serious effects Absorbed through cell membrane of lower forms	In skeletal structures and in supporting structures of certain Protozoa Poriphera and higher forms	Protective and structural component of various lower animal forms	Primarily in urine of vertebrates
Sodium	Widely distributed in foods as inorganic salt More in foods of animal origin than in foods of plant origin Taken as NaCl by many higher vertebrates including man. Absorbed from intestine in higher forms and through gills and cell membranes in lower forms	Major part of body sodium is extracellular much in bone Some intracellular Tissues vary in concentration of intracellular sodium muscle containing only small amounts Data on othe than mammalian forms not available	Chief cation of extracellular water Essential for proper external environment of cells Chief cation of intestinal secretions Salts are important buffers of plasma extracellular water and urine	Primarily in urine Variable quantities in sweat Small amounts in feces
Sulfur	As inorganic sulfates organic sulfates and sulfhydryl sulfur of cystine and methionine	Small amount of sulfate in extracellular H_2O Relatively large amount in proteins and small amount in certain lipids	Essential component of many proteins Sulfuric acid secreted as digestive fluid in Ascidia Sulfate is important anion in intracellular fluid. Sulfat used in detoxification reaction .	Mostly in urine as sulfates and sulfhydryl compounds
Vanadium	Extracted from marine muds by Ascidia.	In blood respiratory pigment of marine worm Ascidia.	Component of respiratory pigment hich provides oxygen transport in Ascidia	Mostly in feces

87 CHEMICAL ELEMENTS FUNCTIONS ANIMALS (Concluded)

The functions listed in the table require the specific elements noted. In addition carbon hydrogen, nitrogen oxygen phosphorus and sulfur are required for the functions of synthesis of structural proteins carbohydrates fats and other organic compounds and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Zinc	Traces present in most foods Absorbed from gastrointestinal tract; in lower forms through cell membrane	Largest quantities in pancreas hair nails bone Very large concentrations in certain oysters and in herring	Prosthetic group of carbonic anhydrase Indispensable for nutrition of growing rat Also required by adult for reproduction. Needed for activation of certain proteinases	Mainly by feces

88 TRACE ELEMENTS FUNCTIONS ANIMALS

Element	Biologically Important Compounds or Ions	Metabolic Role	Deficiency Manifestations	Toxic Manifestations	Quantitative Considerations: Normal Levels or Requirements	Quantitative Considerations: Toxic Levels
(A)	(B)	(C)	(D)	(E)	(F)	(G)
Cobalt	Vitamin B_{12} Vitamin B_{12a} or b Vitamin B_{12c}	Growth promotion (B_{12}, chick) Production of labile methyl groups and transmethylation. Synthesis of ribonucleic acid	Lethargy wasting, inanition, anemia, fatty liver death (sheep, cattle) Addisonian type pernicious anemia (man) Demyelination combined system disease (man)	Polycythemia (rat and other mammals birds and amphibia) Death (rat) Degeneration of alpha cells of pancreatic islets	3.0 μg vitamin B_{12}/day in pernicious anemia	50 mg Co^{++}/kg body wt/day (growth failure in rat)
Copper	Hemocyanin. Tyrosinase Ascorbic acid oxidase Hemocuprein. Hepatocuprein Transferrin. Turacin.	Respiratory pigment (Mollusca and Arthropoda) Keratinization, pigmentation of hair Myelinization of nerve Erythropoiesis Iron metabolism.	Achromotrichia and impairment of keratinization. Anemia. Hemosiderosis Cachexia. Inhibition of growth. Ataxia. Cardiac decompensation. Eventually death (all above symptoms observed in cattle and sheep) Microcytic hypochromic anemia (rabbit, sheep).	Hemolytic crises Jaundice Hemoglobinuria. Death (sheep, cattle)	ca 10 μg/100 ml blood (man) 2 mg/day daily requirement (man) 10 mg Cu/day according to Mo^{++} and SO_4 in diet (sheep) 100 μg Cu/100 ml blood (sheep, cattle)	20-50 mg Cu/day causing excess storage which may result in death (sheep) 0.5 mg Cu as chloride lethal dose (rabbit) 200-400 g Cu as sulfate, lethal dose (cattle)
Fluorine	F^-	No evidence that it is essential. Optimum amount in teeth is associated with resistance to caries		Acute gastroenteritis vomiting, pain, and diarrhea (man) Marked fall in blood pressure (man) Convulsions Mottled enamel (man) Osteosclerosis (man) Growth inhibition (rat) Disturbance of ovarian, pituitary and thyroid function (rat) Phosphatase inhibition. Esterase inhibition. Enolase inhibition.	1.0-2.0 p.p.m. F^- in H_2O will reduce caries in children	0.5 g/kg body wt orally acute dose (mammals) 3.0-4.0 p.p.m. F^- in H_2O (production of mottled enamel rat)

88 TRACE ELEMENTS FUNCTIONS ANIMALS (Concluded)

Element	Biologically Important Compounds or Ions	Metabolic Role	Deficiency Manifestations	Toxic Manifestations	Quantitative Consideration: Normal Levels or Requirements	Quantitative Consideration: Toxic Levels
(A)	(B)	(C)	(D)	(E)	(F)	(G)
Iodine	I^- Monoiodotyrosine Diiodotyrosine Thyroxine Thyroglobulin 3 5 3 triiodothyronine	Promotion of growth and development. Maintenance of normal metaboli rate I^-; resorption of inflammatory lesions.	Cretinism or myxedema (children) Myxedema (man) Goiter	Hyperthyroidism, excess thyroxine Angioneurotic edema, excess I^- Iodism causing salivation, coryza, skin lesions, headache bloody diarrhea.	3 µg I^-/kg body wt daily requirement. 4.45 µg%, normal whole blood iodine	
Iron	Hemoglobin Myoglobin. Cytochromes Cytochrome oxidase Catalase Ferritin Verdoperoxidase	Transportation of O_2 and CO_2 Redox catalysis Dissociation of H_2O_2	Fatigue and listlessness Sore tongue Angular stomatitis Dysphagia Koilonychia. Microcytic, hypochromic anemia (man)	Gastroenteritis acute hemorrhagic gastritis, liver damage caused from oral administration of ferrous sulfate Flushing, nausea and vomiting, lacrimation, and paresthesia caused from intravenous administration of ferrous sulfate Hemochromatosis caused by excessive absorption not normal intake due to metabolic abnormality.	♂12 mg orally daily (man) ♀15 mg orally daily (man) ♂100-150 µg%, ♀90-150 µg%, serum iron levels	6-10 g ferrous sulfate orally 1/2g colloidal ferric hydroxide or oxide intravenously
Manganese	Mn^{++}	Essential for normal reproduction, lactation, bone formation, and growth. Arginase activation. Leucylpeptidase activation Oxaloacetic car boxylase activation. Phosphoglucomutase activation Phosphatase activation. Function in choline metabolism.	Growth impairment (rabbit, rat, mouse) Congenital debility (rat) Sterility with testicular atrophy and estrus cycle irregularity (rat rabbit) Skeletal abnormalities (rat chick rabbit) Perosis (chick)	Parkinsonism-like disturbance of speech and gait muscular weakness tremor and loss of normal vigor (man) Liver damage	♂0.17 µg% ♀0.15 µg%	
Zinc	Carbonic anhydrase Zinc uroporphyrin. Zinc coproporphyrin. Hemocyanin. Zinc-insulin Zn^{++} Zinc protein.	Catalysis of the reactions CO_2 $H_2O \rightleftharpoons H_2CO_3$ for release of CO_2 at the lung alveoli; for uptake of CO_2 at the tissue cells; for the production of HCl in the gastric mucosa and for renal tubular control of urinary pH. Blood respiratory pigment of the snail Activator of leucyldiglycinase.	Growth inhibition, cachexia, posterior sulcus disease (mouse) Achromotrichia. Dermatitis and alopecia (rat) Elevation of blood uric acid, reduced blood alkaline phosphatase low pancreatic amylase (rat)	Metal fume fever (man) Anemia (rat)	8.8 ± 2 µg per ml whole blood (man).	2 mg/kg body wt as Zn gluconate (man).

89 THE VITAMINS: THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES

VITAMIN A (Anti-xerophthalmia factor; axerophthol)

Required by all vertebrates studied, including man, cattle, dog, guinea pig, hedgehog, horse, monkey, rabbit, rat, chicken, turkey. May be formed within the organism from one of the carotenoid provitamins: alpha-, beta-, gamma-carotene, or cryptoxanthin. Exists as vitamin A_1 in marine fishes and land vertebrates; as both A_1 and A_2 in amphibia and anadromous and catadromous fishes; and as A_2 (in place of or in addition to A_1) in fresh water fishes.

Functions	Signs of Deficiency[1,2]	Signs of Excess[3]
(A)	(B)	(C)
Stimulates growth and development to normal (Man, pig, rat, others) Maintains the health of epithelium. Vitamin A (primary alcohol $C_{19}H_{27}CH_2OH$) is precursor for retinene (corresponding aldehyde $C_{19}H_{27}CHO$) which with the visual proteins ("opsins") forms the photosensitive visual pigments (rhodopsin, porphyropsin, iodopsin). Diphosphopyridine nucleotide (contains nicotinamide, q.v.) and retinene reductase (alcohol dehydrogenase) are involved in the reactions	General: Retarded growth of young (Man, rat, chick, turkey); inability to stand on hind legs (Pig) Bone: Localized overgrowth (Cattle, rat) Eye: Retina—synthesis and regeneration of visual pigments decreased; night blindness; visual acuity impaired; photophobia (Man). Cornea, sclera, lacrimal glands and ducts, conjunctiva—degenerative changes as with other epithelium (q.v.); may lead to xerophthalmia keratomalacia in severe deficiency (Man, rat) Epithelium: Skin (Man, rat) and mucosae (Man), particularly of upper respiratory tract, sinuses, bronchii, bronchioles, genitourinary tract—metaplasia, hyperkeratinization, cornification, desquamation varying in degree with severity and duration of deficiency Neural: Optic nerve degeneration, possible result of skull overgrowth and pressure (Cattle, rat) Reproduction: Decreased egg production (Chicken); irregular estrus—sterility, male (Rat) Teeth: Odontoblast atrophy (Man, rat)	Blood: Hypoprothrombinemia (Rat); increased serum lipids, phosphatase; decreased serum proteins (Man) Bone: Fragility, hyperostosis, cortical thickening of long bones, periosteal swellings, pain (Man) Epithelium: Dryness, exfoliation; hair sparse and rough; mouth desquamation; hyperemia of skin and mucosae (Man) Liver: Enlargement (Man). Vascular: Telangiectasis

ASCORBIC ACID (Vitamin C; anti-scorbutic factor)

Required by man and other primates, guinea pig.

Functions	Signs of Deficiency[1,4]	Signs of Excess
(A)	(B)	(C)
Protects adrenal oxy-steroids from destruction by liver (Rat) As an anti-oxidant protects hydrogen carriers Promotes oxidation of fatty acids; participates in oxidation of aromatic amino acids Promotes conversion of folic acid to folinic acid. *Essential for formation of* intercellular substances: collagen, osseín, dentine Increases phagocytic activity Prevention and treatment of scurvy (Primates, guinea pig) Alleviates some effects of vitamin A lack and moderate excess; in large amounts alleviates effects of thiamine and pantothenic acid (cont'd next page)	General: Loss of appetite, decline in physical activity; retarded, defective wound healing; general weakness in organs with high content of intercellular substance and particularly those with high calcium content. Skin, hair: Follicular keratosis (Man); loss of luster, roughening of fur and hair Bone: Disorientation of cells in growing regions; beading of ribs; failure of chondroblast and osteoblast differentiation and maturation. Teeth: Disorientation of cells in growing region; failure of differentiation and maturation of ameloblasts (enamel organ); loosening of teeth in their sockets (Primates); swollen gums Hematopoiesis: Anemia with decrease in red cells and hemoglobin; increase in circulating leukocytes Fibroblasts: Failure of differentiation and maturation. Vascular: Capillary hemorrhages, particularly in subcutaneous and intra-muscular areas Muscle: Swelling, atrophy, waxy degeneration of skeletal muscle; soreness of muscles leading to assumption of fixed, awkward posture. Adrenals: Increase in cholesterol content in early deficiency, decrease in late deficiency Other effects: Reduction of cytoplasm and indistinctness (cont'd next page)	Hypervitaminosis doubtful if calcium content of diet is sufficient. Massive doses by injection lead to sudden death.

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /2/ Some causes of deficiency signs, other than dietary deficiency of the vitamin, are: any factor impairing digestion or absorption of fat, as inflammation of intestinal mucosa, sprue (cf. Folic acid) or chronic diarrhea; excessive ingestion of mineral oil; hyperthyroidism (inhibits conversion of provitamins to vitamin A). /3/ Wide margin of safety between amounts recommended for normal intake, prophylaxis, and therapeutic use. /4/ Summation of deficiency effects makes up the syndrome of scurvy, which may vary in extent and degree with extent of deficiency.

89 THE VITAMINS: THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

Ascorbic Acid (Concluded)

Functions	Signs of Deficiency[1]	Signs of Excess
(A)	(B)	(C)
lack (Rat); prevents development of deficiency signs on Vitamin E deficient diets (Chick, guinea pig). Treatment of shock, wounds, infections	of cell membrane. Increased respiration rate early in deficiency, decrease in late stages; lowering of temperature in late stages	

BIOTIN

(Anti-egg white factor; vitamin H; coenzyme R; factor S; factor W; factor X; bios IIB)

Probably required by most or all vertebrates. The need for the vitamin may be met under normal circumstances by intestinal bacterial synthesis. Need demonstrated for man, calf, dog, monkey, mouse, rabbit, rat, chicken, turkey

Functions	Signs of Deficiency[5]	Signs of Excess
(A)	(B)	(C)
A fundamental growth factor for all vertebrates? Believed to be required by all rapidly growing tissues. Involved in such metabolic processes as carboxylation and decarboxylation of Krebs Cycle acids; deamination of aspartic acid, serine, threonine; synthesis of citrulline; synthesis of unsaturated fatty acids. Improves lactation (Rat)	Skin: Seborrheic skin pathology. Scaly, greasy dermatitis (Dog, monkey, rat, rabbit, chicken) followed by extreme hyperkeratosis after long deficiency. Scaly dermatitis after a period of heavy intake of dried egg white has been demonstrated in volunteers fed 200 grams of egg white daily (Man) Skin appendages: Spectacle alopecia (baldness around eyes: rodents); alopecia (loss of hair; monkey) may be extreme Oral tissues: Atrophy of lingual papillae (Man) Neuromuscular: Spasticity (Rat); paralysis of hind quarters (Rat) Cardiac: Precordial distress; electrocardiographic changes (Man) Other: Anorexia, lassitude, sleeplessness, muscle pain (Man)	Sufficiently detailed and critical studies not yet made

CHOLINE

(No single compound analogous to choline can carry out all of the functions of the vitamin, although several compounds can replace choline in one or more of its functions.)

Required by most or all vertebrates, especially the young including dog, guinea pig, rat, chicken, turkey

Functions[6]	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
Source of transferable (labile) methyl (CH_3) groups in metabolism. Before acting as methyl donor, choline is enzymatically transformed to betaine which transfers the methyl group. May be readily replaced as a methyl donor by betaine, dimethyl thetine, or (cont'd next page)	General: Increased mortality (Chicken, turkey) Liver: Fatty degeneration, cirrhosis (Dog, rabbit, rat); prolonged prothrombin and bromsulphalein times, changes being marked in animals on high protein diets (Rat); liver carcinoma from chronic deficiency (Mouse, rat, chicken) Blood serum: Increased serum phosphatase (Rat) Kidney: Enlargement, hemorrhagic congestion, necrosis of renal tubule epithelium and glomeruli (Rat); granular atrophy; hypertension in consequence of early kidney lesions; decrease in alkaline phosphatase activity and fat deposition (Rat) Nervous system: Paralysis (Young rat) (cont'd next page)	Hematopoiesis: Inhibition of erythrocyte formation (Dog) Digestive system: Diarrhea (Man) Vascular: Edema of legs (Man)

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /5/ Spontaneous deficiency is extremely rare, although reported for the chick. Feeding of raw egg white (active agent, avidin) is necessary to produce deficiency signs in animals. Avidin and biotin form a complex in the intestine which renders the vitamin unavailable to the organism. /6/ The following therapeutic uses of choline have been noted: cure of fatty liver and certain forms of liver cirrhosis (dog, rat); prevention of perosis ("slipped tendon") (chicken, turkey)]

89 THE VITAMINS: THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

Choline (Concluded)

Functions	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
methionine. Donor of methyl groups[7] for synthesis of methionine (in presence of homocystine), purines, etc.	Reproduction: Decreased egg production, ovarian abortion (Chicken, turkey). Vascular: Intracranial bleeding in young, born of choline deficient females (Rat)	
Synthesis of phospholipids, i.e., lecithin. Participates in creatine formation (Rat). Precursor of acetylcholine. Essential for normal nutrition and egg production (Chicken). Essential for lactation (Hamster, rat). Necessary for normal liver function (Dog, mouse, rat, chicken). A direct catalytic role of choline in intermediate metabolism has not been demonstrated.		

COBALAMIN[8]
(Vitamin B_{12}; vitamin B_{12a}; vitamin B_{12b}; cyanocobalamin; hydroxycobalamin)

Required by most or all vertebrates studied.

Functions[9]	Signs of Deficiency[1]	Signs of Excess
(A)	(B)	(C)
General growth factor (Man, mouse, rat, swine, chicken, turkey). Utilization of orally administered cobalamin is potentiated by gastric juice; this suggests the presence of an "intrinsic" factor necessary for the utilization of cobalamin, the "extrinsic" factor. In methylation reactions (Rat, chick). Combined action with folic acid group.	Hematopoietic tissue: Megaloblastic bone marrow (Man). Blood: Macrocytic, hyperchromic anemia (Man). Neural: Degenerative changes in the spinal cord. Oral tissue: Glossitis (Man)	Polycythemia of non-ruminant animals has been reported.

VITAMIN D
(Anti-rachitic factor; calciferol; vitamin D_2; 7-dehydrocholesterol; vitamin D_3)

Required by most or all vertebrates studied. Under the influence of ultraviolet light, the vitamin may be formed from ergosterol (a vegetable sterol, precursor of D_2) or 7-dehydrocholesterol (an animal sterol, precursor of D_3)

Functions	Signs of Deficiency[1,10]	Signs of Excess[11]
(A)	(B)	(C)
Essential to normal development of bone. Enhances net absorption and retention of Ca and P; reduces excretion of P in feces; promotes P reabsorption by the renal (cont'd next page)	General: Retardation of growth (Man, others). Bone: Rickets. Skeletal abnormalities and deformities[12] varying with degree and duration of deficiency (Man, rat, others). Rapidly growing regions are most affected, e.g., junction of epiphysis and diaphysis, long bones; areas of proliferation, flat bones. Irregular, disordered growth pattern, deficient calcification; persistent over-proliferation of cartilage; persistent irregular calcification of osteoid matrix; enlargement of ends of long bones; softness, weakness of bones, and deformation by (cont'd next page)	General: Early symptoms are anorexia, thirst, lassitude, urinary urgency with or without polyuria. Later symptoms are nausea, vomiting, diarrhea, abdominal discomfort leading to weight loss and debility (cont'd next page)

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /7/ Some synthesis of CH_3 occurs in the metabolism of glycine, alanine, serine, histidine, tryptophan. /8/ Probably identical with the anti-pernicious anemia principle of liver. /9/ The following therapeutic uses of cobalamin have been noted: treatment of pernicious anemia--the vitamin is anti-anemic, relieves the lingual manifestations and reverses the degenerative changes in the spinal cord unless damage is irreversible (Man); treatment of sprue (Man). /10/ Some causes of deficiency signs, other than dietary deficiency of the vitamin, are any factor impairing digestion or absorption of fat, as inflammation of intestinal mucosa, sprue, or chronic diarrhea; excessive ingestion of mineral oil; relatively greater requirement during pregnancy and lactation. /11/ The amount of dietary vitamin D which will produce signs of excess varies with individuals within the same species and at different times within the same individual. /12/ Skeletal abnormalities and deformities are the scars and residue of functional and structural change and may persist long after the deficiency has been relieved. Degree of restoration may be extensive and continue over long periods.

89 THE VITAMINS, THEIR FUNCTIONS SIGNS OF DEFICIENCY AND EXCESS MAN AND OTHER VERTEBRATES (Continued)

Vitamin D (Concluded)

Functions	Signs of Deficiency[1]	Signs of Excess
(A)	(B)	(C)
tubules Maintains alkaline phosphotase at the bone site The vitamin is particularly effective during the period of rapid skeletal growth.	stress and posture; increased thickness of bone shaft; osteomalacia: decalcification fragility of non-growing bone Teeth: Faulty calcification, most frequent in the permanent dentition; defects difficult to distinguish from deficiencies of vitamins A and C Mineral metabolism: Hypocalcemia, hypophosphatemia; derangement of Ca and P deposition in bone matrix and teeth. Blood plasma: Increase in plasma phosphatase Muscle Myasthenia; atony skeletal and gut muscle Neuromuscular: Tetany convulsions spasmodic closure of glottis (Man, rat)	Blood: Hypercalcemia, hyperphosphatemia. Mineral Metabolism: Deposition of Ca salts in various organs arteries and arterioles; metastatic calcification may occur without hypercalcemia in the dog. Bone: Dense calcification in zone of provisional calcification in long bone metaphyses at the expense of diaphyseal calcification, in infants and growing young (Man) Renal: Ca deposits with resulting kidney damage and renal dysfunction; increased urinary excretion of Ca and P Other: Continued hypervitaminosis leads to death. Since vitamin D is stored, excessive doses may be cumulative Hypercalcemia, high urinary Ca and renal damage have been noted eight months after treatment (125,000-unit doses daily)

VITAMIN E[1]
(Alpha-, beta- delta- gamma-tocopherols; anti-sterility factor)

Required by cattle dog, guinea pig, hamster mink mouse rabbit rat, swine chicken, duck, turkey Significance if any in human nutrition, has not yet been established

Functions[13]	Signs of Deficiency[10]	Signs of Excess
(A)	(B)	(C)
Biological anti-oxidant; protects unsaturated fatty acids vitamin A against peroxidation. Participates in oxidation-reduction reactions	Reproductive organs: Irreparable degeneration of the testicular germinal epithelium; testicular degeneration with decrease in weight of testes (Bull mouse rat, chicken); uterine necrosis, seminal vesicle necrosis (Rat) Reproduction: Resorptive failure of pregnancy after death of the fetus, in severe deficiency; prolonged gestation with still-birth or death postpartum of the newborn, in moderate deficiency (Rat) Reproductive failure (Swine) Reduced egg hatchability death of the embryo (Chicken) Muscular: Acute muscle degeneration with swelling, hyalinization necrosis of striated muscle and (in some species) cardiac muscle (Dog, guinea pig, hamster rabbit, rat chicken, duck) Isolated degeneration of smooth muscle of gizzard (Turkey) Neural: Acute encephalomalacia, degeneration of the cerebellum, nerve cell degeneration (Chick) Neuromuscular: Ataxia, tremors weakness, opisthotonus (retraction of head--chicken) Paralysis (suckling rat, born of vitamin E deficient mother) Urine: Creatinuria. Vascular: Generalized exudative diathesis (Chick) Liver: Necrosis degeneration (Mouse rat swine) Metabolic: Increased oxygen uptake in vitro of muscle tissue from vitamin E deficient individuals (Hamster rabbit, rat)	

/1/ Deficiency signs when not irreversible may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /10/ Some causes of deficiency signs other than dietary deficiency of the vitamin, are: any factor impairing digestion or absorption of fat as inflammation of intestinal mucosa, sprue or chronic diarrhea; excessive ingestion of mineral oil; relatively greater requirement during pregnancy and lactation. /13/ The following therapeutic uses for vitamin E have been noted: treatment of skin collagenoses (man); protects against nutritional encephalomalacia (chick) experimentally protects against such toxic agents as carbon tetrachloride chloroform, alloxan; cures and prevents the muscle lesions which develop in young of vitamin E deficient mothers (guinea pig, hamster rabbit rat suckling) and of older rat on vitamin E deficient diets.

89 THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

FOLIC ACID GROUP

(Folacin; pteroylglutamic acid (PGA); folinic acid; citrovorum factor; vitamin M; vitamin B_c; vitamin B_{10}; factor U; L. casei factor; Norite eluate factor)

Required by most or all vertebrates studied, except ruminants and others whose need is satisfied by intestinal bacterial synthesis. The essentiality of the vitamin to man, dog, guinea pig, fox, mink, sulfa treated lamb and rat, chicken, duck, goose, turkey, fish, is established.

Functions[14]	Signs of Deficiency[1]	Signs of Excess[15]
(A)	(B)	(C)
An essential growth and hematopoietic factor (Monkey, fox, mink, chick on purified rations) Production and utilization of formate Methylation reactions, e.g. ethanolamine to choline, homocysteine to methionine, nicotinamide to N-methyl nicotinamide, pyrimidine ring to thymine Introduction of the 2 and 8-carbon atoms into the purine ring and the middle carbon into histidine Tyrosine oxidation.	General: Retardation of growth Blood, hematopoietic tissues: Sprue (Man, monkey); megaloblastic bone marrow (Man, many others); macrocytic hyperchromic anemia (Man, monkey); macrocytic anemia, with ultimate anisocytosis (Chick, turkey); Cytopenia (Monkey, chick); leukocyte abnormalities (Monkey, rat, chick); infarction of the spleen (Rat) Skin, skin appendages: Poor feather structure (Chicken, turkey); abnormal feather pigmentation (Chicken); graying of the pelage (Rat) Bone: Perosis ("slipped tendon"--Chicken, turkey) Reproduction: Impaired reproduction (Rat, chicken); lowered hatchability of eggs (Chicken) Mammary gland: Impaired lactation (Rat) Development: Hydrocephalus (Rat) Neuromuscular: Neck paralysis (Goose, turkey) Intestinal: Diarrhea and the absorptive difficulties associated with the syndrome of sprue (disorders of calcium metabolism; impaired absorption of fat and of fat soluble and water soluble vitamins)	Relatively non-toxic Males more resistant than females (Mouse) Death by obstruction of the renal tubules with precipitated folic acid follows intake of toxic amounts

INOSITOL (MESO-)

(Mouse anti-alopecia factor; Bios I)

Required by mouse and possibly cotton rat and hamster

Functions	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
Stimulates growth when added to rations deficient in thiamine (Rat) and to rations containing sulfonamides (Rat, swine)	Skin and skin appendages: Characteristic alopecia (loss of hair--Mouse); severe dermatitis following alopecia (Mouse)	Non-toxic as far as known
Lipotropic factor essential in metabolism of fat and cholesterol. Active with choline in preventing some types of fatty liver (Rats). Prevents encephalomalacia and exudative diathesis in vitamin E deficiency (Chicken). Suggested essential to reproduction (Hamster)		

PARA-AMINOBENZOIC ACID ("PABA")

Required by: None?

Functions	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
The vitamin-like action in vertebrates can probably be entirely explained by the action of folic acid ([illegible]) of which it is a structural component.		

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /14/ The following therapeutic uses of the vitamin have been noted: Treatment of sprue (man); nutritional macrocytic anemia; certain megaloblastic macrocytic anemias of infancy (man); macrocytic anemia of pregnancy (man); added to practical rations as growth stimulation factor (mink). Folic acid antagonists, e.g. aminopterin, used in treatment of leukemia and certain other diseases (man). /15/ Intravenous LD_{50}=600 mg/kg body weight (mouse); 500 mg/kg (rat); 410 mg/kg (rabbit); 120 mg/kg (guinea pig)

89 THE VITAMINS THEIR FUNCTIONS SIGNS OF DEFICIENCY AND EXCESS MAN AND OTHER VERTEBRATES (Continued)

VITAMIN K
(Anti-hemorrhagic factor; phylloquinone)[16]

Required by man dog, mouse rabbit rat, canary chicken, duck, goose pigeon, turkey In mammals bacterial synthesis may satisfy the need in whole or in part and demonstration of essentiality depends on rigid control of bacterial synthesis

Functions[17]	Signs of Deficiency[1,10,18]	Signs of Excess
(A)	(B)	(C)
Essential for the production of prothrombin[19]; (the vitamin itself does not enter into the structure of the prothrombin molecule)	Liver: Decline or failure of prothrombin synthesis Blood Decrease in blood prothrombin content resulting in: increased bleeding tendency after even slight trauma; multiple hemorrhages throughout all tissues (Man, chicken); increased clotting time (Man others)	Gastrointestinal Vomiting (Man); vomiting after oral dose of 180 mg of menadione (synthetic vitamin) (Dog) Urine Porphyrinuria (Man, dog); albuminuria (Dog) Blood: Prolonged clotting time (Rabbit); cytopenia, hemoglobinemia (Mouse)

NIACIN (-AMIDE)
(Nicotinic acid (-amide); pellagra preventive (P P) factor; anti-blacktongue factor)

Required by all vertebrates studied except calf horse sheep whose need i supplied by intestinal flora The rat chicken, turkey and other animals are able to synthesize niacin from tryptophan. Animal tissues contain the vitamin almost exclusively as niacinamide; plant tissues contain it mainly in the form of niacin.

Functions	Signs of Deficiency[1,20]	Signs of Excess[21]
(A)	(B)	(C)
A component of di and triphosphopyridine nucleotides (DPN Coenzyme I) TPN Coenzyme II) which function as hydrogen acceptors in more than 50 metaboli reactions DPN catalyzes the conversion of vitamin A_1 to rhodopsin and retinene to vitamin A. Stimulates gastri secretion The vitamin i synergistic with foli acid	General Delayed growth and development of young; lowered oxidation rate in some tissues; dermatitis, diarrhea, and dementia (the triad of pellagra) Epithelium Bilateral, symmetrical dermatitis aggravated by sunlight heat inflammation (Man only); rarefaction of cutis keratinization atrophy of sebaceous glands desquamation. Swollen gills (Trout) Poor feathering (Chick) Digestive tract Stomatitis (Man, dog fox, swine chicken, turkey); smooth glossitis (Man); blacktongue (Dog, cat chicken); large intestine—atrophy ulceration, cyst formation (Man dog, swine); diarrhea (Man, dog, calf rabbit chicken, duck, turkey); achlorhydria (Man swine); salivary drooling (Dog) Hematopoietic Macrocyti anemia (Man dog, rabbit swine); leukopeni (Dog, rabbit) Neural Degenerative changes (Man dog) retrobulbar neuritis (Man); encephalopathy headache dizziness depression, delusions dementia; locomotor difficulties tremors jerky movements rigidity; altered tendon reflexes numbness paralysis (Man) Bone Perosis (Slipped tendon —Chick, turkey poult)	General Death follows very large doses; dogs on 2 grams/day di within 20 days; 2% niacinamide in diet inhi bits growth (chick); 1% causes fatty livers; large doses of niacin cause ketosis (Rat) Epithelium: Burning and itching of skin; elevation of skin temperature (Man) Vascular: Peripheral vasodilation (Man) Neural Paralysi of the respiratory center (Rat)

/1/ Deficiency igns when not irreversible may be alleviated, and the animal restored to health by the administration of therapeutic doses of the vitamin. /10/ Some causes of deficiency igns othe than dietary deficiency of the vitamin, are any factor impairing digestion or absorption of fat, as inflammation of intestinal mucosa, sprue or chroni diarrhea; excessive ingestion of mineral oil; relatively greater requirement during pregnancy and lactation. /16/ A number of syntheti products having a quinoid nucleus have vitamin K activity .g menadione (2-methyl-1,4-naphthoquinone) The synthetics tend to be more toxic (in excessive amounts) than the naturally occurring vitamin. /17/ The following therapeuti uses of the vitamin have been noted: stimulation of prothrombin production; reduction of prothrombin clotting time Ineffective in treatment of hemorrhagi diseases not due to prothrombin deficiency .g hemophilia, thrombocytopenia. In hypoprothrombinemia of the newborn, prevention and treatment (man) Counteracts effects of dicoumarol (man, others) /18/ Vitamin K deficiency does not precipitate bleeding; the abnormality is failure of clotting afte bleeding has begun. /19/ The prothrombin stimulating properties of vitamin K act through the ite of prothrombin production (liver) and the vitamin, even in large amounts is ineffective if the prothrombin producing tissues are damaged or impaired. /20/ The syndrome of deficiency symptoms is referred to as "Pellagra in man and "blacktongue in dogs cats and other animals /21/ Rati therapeutic dose toxic dose 1 1000

PANTOTHENIC ACID

(Pantothen; filtrate factor; chick anti-dermatitis factor; chick anti pellagra factor; factor II; anti-chromotrichia factor; anti-gray hair factor)

Required by most or all vertebrates studied including calf dog, fox guinea pig, hamster monkey mouse swine rat chicken duck pigeon turkey

Functions[22]	Signs of Deficiency	Signs of Excess[23]
(A)	(B)	(C)
Growth factor for the animal mentioned above As component of Coenzyme A functions in: enzymatic acetylation; fat protein carbohydrate metabolism; phospholipid and steroid synthesis	General Retarded growth. Skin Specific dermatitis of mouth and feet (Chicken); eczematous dermatitis (Rat) Hair: Achromotrichia (graying) (Monkey dog, fox rat mouse); spectacle alopecia (Rat) Tongue Ulceration (Rat) Neural Myelin degeneration of peripheral nerves (Chick); chromatolysis of dorsal root ganglion cells (Chick swine) Neuromuscular: Spastic abnormalities of hind quarters abnormal gait ataxia (Dog, mouse swine); convulsions (Dog) Endocrine glands Hemorrhagic necrosis of adrenals Exocrine glands: Secretion of red pigment by the Harderian gland ("bloody pigment"—Rat) Gastrointestinal Diarrhea with bloody stools (Dog); anorexia, diarrhea, colitis (Monkey swine); necrosis of intestinal epithelium abscesses followed by ulceration (Rat) Hematopoietic Anemia (Dog, rat monkey swine) Kidney: Necrosis (Rat) Liver Increased deposition of fat (Dog, chick) Other: Burning sensations of hands feet (Man); collapse associated with decreased blood glucose and blood chloride; increased non-protein nitrogen in severe deficiency (Dog); death in severe deficiency	100 grams may be given to man intravenously without ill effects

PYRIDOXINE (VITAMIN B_6) GROUP[24]

(Pyridoxal pyridoxamine pyridoxine; anti-acrodynia factor; factor Y)

Required by most or all vertebrates studied, including man; synthesized by intestinal organisms in rat Requirement by animals is increased with increased dietary protein methionine linseed oil sucrose and apparently decreased with increased dietary essential fatty acids choline biotin pantothenic acid, aureomycin. The vitamin occurs largely as pyridoxal in animal products and as pyridoxamine in plant products

Functions[25]	Signs of Deficiency	Signs of Excess[26]
(A)	(B)	(C)
Growth factor (Man monkey rat chicken, duck turkey) Functions biochemically in the form of pyridoxal phosphate as coenzyme for transaminase and codecarboxylase systems kynureninase cystathionase serine and threonine dehydrase cysteine desulfhydrase and racemizing enzymes; in deamination of amino acids and the formation of urea nitrogen; in conversion of tryptophan to niacin; in metabolism of (cont d next page)	General: Retarded growth (Man: infant monkey rat chick); appetite and weight loss reduced egg production death (Chicken) Cardio-vascular Hypochromic anemia (Man. infant); polymorphonuclear leukocytosis lymphopenia (Man); hypochromic microcytic anemia with anisocytosis and irregular reticulocytosis (Dog, swine monkey duck chicken); poikilocytosis (Cattle); dilatation, hypertrophy of right auricle and ventricle; increased plasma urea and NPN; tachycardia and cardiac embarrassment (Rat); mucus accumulation in thorax (Dog); impaired antibody production (Rat) Neural: Degeneration in myelin sheaths of peripheral nerves and spinal cord (Dog, swine); convulsions epileptiform fits (Rat swine chicken); ataxia (Swine); convulsions (Man infant); weakness nervousness irritability insomnia (Man)[27] Epithelium: Seborrhea like lesions about eyes nose mouth; cheilosis glossitis stomatitis (Man[27]); denudation of hair from paws snout ears(?) (cont d next page)	Convulsions 24 hr after LD_{50} dose (Rat) Daily feeding of 10 mg/kg body weight for 3 months had no effect (Monkey dog rat)

/22/ Possibly required for prevention of "burning feet" syndrome (Man) /23/ LD_{50} mouse orally 10 g; subcutaneously 2 7 g; intraperitoneally 0 9 g LD_{50} rat subcutaneously 3 4 g/kg body weight /24/ In animals the three forms (pyridoxine -al -amine) are equally active when given by injection but pyridoxine is the most active when administered orally /25/ In addition to its use in the treatment or prevention of pyridoxine-deficiency symptoms the following therapeutic uses of the vitamin have been noted treatment of muscular dystrophies associated with pellagra (Man); hyperemesis gravidarum (nausea of pregnancy); seborrheic dermatitis sicca (Man) /26/ LD_{50} rat subcutaneously 3 g/kg body weight; orally 4 g/kg /27/ Eight volunteers deficiency signs produced by ingestion of desoxypyridoxine

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PYRIDOXINE (VITAMIN B_6) GROUP (Concluded)

Functions (A)	Signs of Deficiency (B)	Signs of Excess (C)
fatty acids Seems to be necessary for normal adrenal-cortical function	thickening of ears (Rat); dermatitis bald patches (Monkey) Urine: Increased urea, ammonia uric acid, creatinine (Dog); tryptophan metabolites in urine (Dog, hamster mouse rat); large amounts of xanthurenic acid (Man) Other: Anorexia, arthritis (Cattle); loss of weight appetite decreased egg production, death (Chicken)	

RIBOFLAVIN
(Vitamin B_2, or G; lactoflavin, ovoflavin hepatoflavin)

Required by most or all vertebrates studied

Functions (A)	Signs of Deficiency[1,28] (B)	Signs of Excess (C)
As riboflavine-5-phosphate a component of a number of flavoprotein enzymes e.g. "Warburg yellow enzyme cytochrome-c-reductase riboflavine-adenine-nucleotide As prosthetic group for various proteins functioning as enzyme hydrogen carriers e.g. D-amino acid oxidase xanthine oxidase succinic dehydrogenase Rol in the visual mechanism of the retina (q) Acts closely with thiamine and niacin which like it are components of important enzyme systems (q)	General: Cessation or retardation of growth (Rat others) Epithelium: Epidermal atrophy dermatitis greasy scaling especially of naso-labial folds cheeks chin (Man); cheilosis angular stomatitis lesions of lip and mouth corners (Man) Neural: Myelin degeneration of nerves (Dog, mouse rat swine chicken); central neuritis (Man); lack of coordination, faulty grasp reflex (Monkey); curled toe paralysis (Chicken); partial paralysis of legs (Rat) Muscular: Muscle weakness (Dog, monkey) Gastrointestinal: Diarrhea, vomiting (Dog) Eye: Mild photophobia, dimness of vision and decline of visual acuity; itching and burning sensations of the eyes; soreness of eyes and lids (Man); cornea—cloudiness, vascularization, cataract, opacity ulceration (Man dog, rat) Embryological: Congenital skeletal malformations in offspring of riboflavine-deficient females (Rat) Intermediate metabolism: Profound disturbance of energy transfer and release	5 000 times the therapeutic dose i tolerated (Rat mouse) Kidney: Toxic amounts intraperitoneally cause anuria, renal concretions (Rat) Neural: Paresthesia itching (Man) Other: Nausea.

THIAMINE
(Vitamin B_1; anti-neuritic factor; aneurin)

Required by most or all vertebrates studied except ruminants whose need i satisfied by ruminal synthesis

Functions (A)	Signs of Deficiency[1,29] (B)	Signs of Excess (C)
Essential for normal growth, development and maintenance of health Essential for normal appetite digestion, gastrointestinal tonus Essential in the normal activity of nerve tissue Essential in carbohydrate metabolism. As the pyrophosphate ester (cont'd next page)	General: Retardation of growth; anorexia (Man, others) Neural: Degeneration of neurons particularly of the vestibular group (Man, others) No peripheral nerve degeneration (Mammals) Polyneuropathies: Convulsions, hyperesthesia, anesthesia (Man, others); opisthotonos (backward retraction of head—pigeon, chicken turkey); neurasthenia of nutritional origin (Man) Cardiac: Dilatation of the heart, myocardial lesions (Dog, fox, rat, swine); bradycardia (Monkey cat dog, rat swine) Vascular: Edema (Dog, fox rat swine) (cont'd next page)	Vascular: Hypotension (Man, dog, rabbit)

/1/ Deficiency signs when not irreversible may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin /28/ Requirement i increased in pregnancy and lactation. /29/ For man, the diverse symptoms are grouped under the syndrome of beri-beri sometimes subdivided into cardiac beri-beri wet" beri-beri dry" (neuriti paraplegi) beri-beri Requirement for thiamine is increased by thyrexin and insulin

89 THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS MAN AND OTHER VERTEBRATES (Concluded)

THIAMINE (Concluded)

	Functions	Signs of Deficiency[1]	Signs of Excess
	(A)	(B)	(C)
297	thiamine is cocarboxylase and as such participates in the decarboxylations oxidations dismutations and condensations which in metabolism lead to CO_2 formation.	Gastrointestinal: Atony spastic colon, dysphagia (Man) Intermediate metabolism: Accumulation of pyruvic acid in blood and tissues Decrease in urinary citric acid excretion (Rat)	

ESSENTIAL UNSATURATED FATTY ACIDS
(Arachidonic acid linoleic acid, linolenic acid)

Required by rat; probably others Ordinarily not regarded as a vitamin

	Functions[30]	Signs of Deficiency	Signs of Excess
	(A)	(B)	(C)
308	Arachidonic linoleic and linolenic acids are essential to growth and reproduction (Rat)	General: Retardation or cessation of growth (Rat); elevated metabolic rate with diminished growth rate (Rat) Skin: Scaling of epidermis on feet and tail (Rat); eczema (Man)	Changes from normal in composition of stored fat.
309	Serve as building units of the phospholipids Catalyze the oxidation of saturated fatty acids in vitro.	Hair: Alopecia (Rat) Reproduction: Delay of sexual development disturbances of ovulation; resorption of the fetus; difficult parturition (Rat); sterility (Rat, mouse dog); loss of sex interest (Rat)	
310	Exercise protective action in pyridoxine deficiency (Rat)	Kidney: Lesions of the kidney and urinary tract (Rat) Blood: Low iodine number in serum fatty acids Other: Increased water intake (Rat)	

/30/ The following therapeutic uses of the compounds have been noted: Cures the characteristic skin lesions associated with unsaturated fatty acid deficiency; used in treatment of certain eczematous skin conditions (Man)

90 NUTRIENT DEFICIENCY EFFECTS ON REPRODUCTION MAMMALS

Majority of studies based on findings in the rat

Deficiency State / Effect	Male				Female: Non-pregnant or Virgin				Female: Pregnant Mother and Fetus							
					Estrous or Menstrual Cycle											
	Prostate and Seminal Vesicle Atrophy	Testis Atrophy or Impairment	Germinal or Tubular Epithelium Degeneration	Spermatogenesis Impairment	Irregular	Cessation	Ovary and Uterus Atrophy	Keratinizing Metaplasia Reproductive Epithelium	Implantation Impairment	Gestation and Parturition Prolonged	Delivery of Puny Young	Congenital Abnormalities Young	Stillborn or Non-viable Young	Fetal Death	Fetal Resorption or Abortion	Lactation Impaired
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
1 Inanition[1,2]	+														+4	
2 Protein[2 3]																
3 "Essential fatty acids"[2 5]																
4 Vitamin A																
5 Biotin	+			+												
6 Cobalamin[6]																
7 Vitamin E[3]			+											7		
8 Folic acid group[3,8]														+		
9 Vitamin K																
10 Pantothenic acid[2 3]															+	
11 Pyridoxine group[3 9]															4	
12 Riboflavin																
13 Thiamine[2]															4	
14 Calcium																
15 Copper																
16 Iodine												+10				
17 Manganese																
18 Phosphorus																
19 Potassium																
20 Sodium																
21 Arginine[11]																
22 Histidine		12														
23 Phenylalanine	+13															
24 Tryptophan																

/1/ Defined differently by every investigator Both qualitative (dietary essentials) and quantitative (calories) deficiencies are present in the majority of studies /2/ Deficiency probably acts vi diminished secretion of pituitary gonadotropins and the resultant hypofunction of the gonads The capacity of the gonads and the accessory reproductive organs to respond to hormonal stimuli is apparently unimpaired. /3/ Effects of deficiency in this nutrient are observed even when the total calorie intake is maintained unchanged. /4/ Pregnancy can be maintained by estrone and progesterone /5/ Linoleic linolenic arachidonic acids. /6/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12b} or B_{12a}) which has approximately the same biological activity /7/ Effect attributed to failure of fetal mesodermal derivatives especially those concerned with hematopoiesi and to abnormalities of the vascular system. /8/ Folic acid is not chemical entity but generic term for pteroylglutamic acid (folacin) vitamin M, vitamin B_c, factor U, L. casei factor Norite eluate factor /9/ Includes pyridoxine pyridoxal pyridoxamine. /10/ Thyroid insufficiency? /11/ Arginine major structural component of nucleoproteins of sperm head. /12/ Also true for leucine /13/ Also true for methionine and threonine

91 FUNCTIONS OF ESSENTIAL ELEMENTS HIGHER PLANTS

Element	Occurrence in Plant[1]	Functions
(A)	(B)	(C)
Boron	Cytoplasmic membranes?	Inverse relationship between boron level and water permeability of membranes and moisture content of tissues The element is necessary for: (a) Cell division and differentiation. (b) Translocation of sucrose and possibly other sugars
Calcium	Calcium pectate Salts of organic acids	Calcium pectate may be a constituent of the middle lamella[2] Calcium precipitates organic acids
Carbon	All organic compounds[3] Bicarbonate ion	Carbon is the key element in all organic molecular structures The ion is involved in anion absorption or exchange
Copper	Tyrosinase Ascorbic acid oxidase Laccase[4]	Tyrosinase is a polyphenoloxidase involved in reduction of molecular oxygen (terminal step in aerobic respiration) The oxidase may be concerned in respiratory oxidation.
Hydrogen	All organic compounds occurring in plants[3] Bicarbonate ion	The element is a component of these compounds The ion is involved in anion absorption or exchange
Iron	Peroxidase Cytochrome oxidase Catalase	Peroxidase breaks down peroxide and transfers active oxygen to oxidizable substances The oxidase plays a role in reduction of molecular oxygen Catalase effects the release of molecular oxygen from hydrogen peroxide
Magnesium	Chlorophyll Co-carboxylase Enolase Hexokinase Magnesium pectate	Chlorophyll is essential for photosynthesis Co-carboxylase is the co-enzyme for the function of carboxylases Enolase is necessary in glycolysis (from 2 phosphoglyceric acid to 2 phosphopyruvic acid) Hexokinase brings about transphosphorylation of glucose[5] Magnesium pectate may be a constituent of the middle lamella[2]
Manganese	Arginase? Unidentified enzyme Unidentified enzyme	Arginase converts arginine to urea The enzyme brings about catabolism of oxaloacetic acid into pyruvic acid and carbon dioxide in respiration The enzyme is apparently required in ascorbic acid synthesis
Molybdenum	Unidentified enzyme?	The element appears to effect the reduction of nitrate to ammonia[5]
Nitrogen	Proteins Chlorophyll Many organic compounds	The element is a component of proteins, the chief organic constituents of protoplasm Chlorophyll is essential for photosynthesis The element is important in the assimilation of sugars
Oxygen	Most organic compounds[3] Bicarbonate ion	The element is a component of these compounds The element is the final receptor of hydrogen in aerobic respiration The ion is involved in anion absorption or exchange

/1/ The element occurs in, or in association with the compound or structure listed. The list is not exhaustive. /2/ The middle lamella is an intercellular layer flanked on each side by the primary cell walls. /3/ These compounds include carbohydrates, fats, proteins, vitamins, hormones, and chlorophyll. /4/ The enzyme is of limited distribution and its function is unknown. /5/ Nature of relationship undetermined.

91 FUNCTIONS OF ESSENTIAL ELEMENTS HIGHER PLANTS (Concluded)

Element	Occurrence in Plant[1]	Functions
(A)	(B)	(C)
Phosphorus	Phospholipids[6] Nucleoprotein Adenosine di and tri phosphates Di and triphosphopyridine nucleotide	Phospholipids are a constituent of cytoplasmic membranes Nucleoprotein is a constituent of the nucleus and the chromosomes These coenzymes are required for phosphorylation reactions glycolysis and synthesis of sucrose starch and proteins These coenzymes accept and/or donate hydrogen in oxidation-reduction reactions
Potassium		The element may be involved in action of fructokinase and other enzyme systems The element facilitates carbohydrate synthesis and translocation of carbohydrates
Sulfur	Cystine and cysteine Glutathione Mustard oil glycosides	These compounds are present in all plant proteins Glutathione may function as a hydrogen carrier in respiration Glycosides may ti up reserve food substances which would otherwise be toxic to cells
Zinc	Unidentified enzyme	The enzyme is directly necessary for synthesis of tryptophan the precursor of indoleaceti acid

/1/ The element occurs in, or in association with the compound or structure listed The list is not exhaustive /6/ For example lecithin

92 SIGNS OF CHEMICAL ELEMENT DEFICIENCY AND EXCESS HIGHER PLANTS

	Nutrient	Deficiency Symptoms	Toxicity Symptoms
	(A)	(B)	(C)
1	Boron	Terminal leaves chlorotic shed prematurely; internodes of terminal shoots shortened, usually rosetting; apical meristems blacken and die general breakdown of meristematic tissue; root branches short stubby Plant dwarfed and stunted. Flower development and seed production usually impaired.	Marginal necrosi in lower leaves remainder of leaves dark green; death of most plants if present in considerabl concentration.
2	Calcium	Leaves chlorotic rolled and curled; breakdown of meristematic tissues in stems and roots in acute cases death; roots poorly developed lack fiber may appear gelatinous Symptoms appear near growing points of stems and roots. Little or no fruiting.	Chlorosis similar to iron or manganese deficiency [1] Zinc and boron deficiency may be induced when soil reaction e g pH is altered.
3	Copper	Wilting of terminal shoots often followed by death; leaf color often faded; carotene formation and pigmentation reduced.	Chlorosis similar to iron deficiency; followed by necrosis permanent wilting of upper leaves; leaves may become wrinkled and necrotic at margins; fibrous roots stubby poorly developed; brownish at tips; reduced growth; extreme cases death.
4	Iron	Interveinal white chlorosis appearing first on young leaves tendency for chlorosis of all aerial parts often becoming necrotic; in some cases leaves may be completely bleached, margins and tips scorched. Usually has an overall effect.	Same as phosphorus or manganese deficiency
5	Magnesium	Mottled chlorosis with veins green and leaf web tissue yellow or white appearing first on old leaves; severely affected leaves may wilt and shed or may abscise without the wilting stage; brittleness of leaves common, necrosis often occurs	Same as calcium deficiency
6	Manganese	Mottled chlorosis with veins green and leaf web tissue yellow or white appearing first on young leaves may spread to old leaves; stems yellowish green often hard and woody Carotene development reduced.	Leaves pale necrotic bronzing at margins; similar to iron deficiency With potato small black spots on stem.
7	Molybdenum	Leaves have light yellow chlorosis; leaf blade may fail to expand.	Lower leaves yellow with brown necrotic areas; in severe cases upper leaves may be stunted, chlorotic and shedding.
8	Nitrogen	In young plants stunted growth and yellowish green leaves; older leaves light green followed by yellowing and drying or shedding, often abundant anthocyanins in veins; shoots short thin growth upright and spindly; blossoming reduced; with apple and peach, fruit highly colored develops slowly small when mature Usually has an overall effect.	Leaves dark green, excessive vegetative growth; high transpiration; reduced yield of seed and fruit crops may secure satisfactory yield of leafy vegetables but reduced quality (lack succulence)
9	Phosphorus	Leaves pale green[2] often anthocyanins (usually purple) in veins may become necrotic; with potato meristematic growth ceases; fruits ripen slowly; plants often dwarfed at maturity	Same as iron deficiency May induce zinc deficiency.
10	Potassium	Leaves usually dark blue green (sometimes bronzed) with marginal chlorosis and necrosis appearing first on old leaves; usually wrinkled, corrugated or crinkled between veins	Leaves yellowish green; reduced growth; tendency toward calcium and magnesium deficiency
11	Sulfur	Leaves light green to yellow appearing first along veins of young leaves; stems often slender	No evidence except as acidity of root medium is influenced.
12	Zinc	Leaves chlorotic and necrotic appearing first on young growth rosetting premature shedding, whitish chlorotic streaks between veins in older leaves and whitening of upper leaves in monocotyledons chlorosis of lower leaves in dicotyledons.[3]	Leaves yellow from zinc induced iron chlorosis.

/1/ Chlorosis due to the physiological unavailability of iron and manganese or reduced potassium. /2/ With potato and certain other vegetables leaves dark green. /3/ Young plants showing deficiency symptoms often lose symptoms when roots penetrate the subsoil.

93 SIGNS OF CHEMICAL ELEMENT DEFICIENCY EIGHT SELECTED PLANTS (Section I)

Species / Element	Alfalf (Medicago sativa)	Apple (Pyrus malus)	Cabbage (Brassica oleracea capitata)	Citrus (Citrus spp.)
(A)	(B)	(C)	(D)	(E)
Boron	Terminal leaves yellow to red followed by death of t minal buds; int rnodes of terminal shoots shortened forming rosette; in severe case blossoms fail to develop	Terminal growth of shoots di back in early spring or late summer internodes shortened; leaves dwarfed chloroti thickened brittle with margins commonly unserrated; fruit may show external cork spots and int rnal necrosis around vascular bundles; bark with lesions	Plants dwarfed; leaves puckered along midrib brittle stiff thick, mottled along margins; petioles with swellings becoming corky; water soaked appearance of pith area in stem of head region	Terminal hoots die back; leaves brownish yellow with water soaked spots vein chlorosi and necrosis shed prematurely; fruit may be small misshapen with small brown areas in rind
Calcium		Young leaves necroti at tip margin or along midrib tips and margin curving old leaves have necrotic areas; root short bulbous dying back from tips after making short growth.	Plants dwarfed growing point dies; young leaves chlorotic rolled ragged becoming necrotic; older leaves dull green.	Shoots di back from tip; leaves have interveinal and marginal chlorosi and necrosis; shed prematurely; roots may decay
Copper	Terminal leaf petioles have epi nasti curvature leaflets fold backward along peti les followed by wilting and death.	Terminal leaves brown spotted followed by necrosi wilt; shoot tips withe and di back; bushy growth	Leaves chlorotic; heads fail to form; growth tunted.	Leaves large dark green twisted and bowed on long soft angular shoot ; in acute cases multiple buds on heavy twigs developing soft shoot di back from tips with reddish excrescences over bark; fruits may be lumpy and covered with reddish brown excrescences gum pocket internally often split and shed; roots may show gumming.
Iron	Terminal leaves chloroti lower leaves remain green; in severe cases entire foliage chloroti ; terminal internodes shortened; flowers fail to form.	Terminal leaves chlorotic spreading downward on twigs; shoots di back when severely affected; fruit highly colored.	Terminal leaves chlorotic	Terminal leaves chlorotic between veins; leaves thin in acute cases yellow to orange and necroti shedding prematurely; fruit sparse small hard coarse light in color
Magnesium	Olde leaves become orange-yellow often with red tints	Older leaves of terminal growth light green to brown blotches between veins often extending to margins shed prematurely; fruit may fail to ripen on tree	Older leaves have interveinal chlorosis brittle puckered; severe chlorosis may be followed by yel lowing around margins and at cente	Older leave chlorotic with wedge of green along midrib followed by chlorosi of entire leaf shed prematurely; shoots die back.
Manganese	Leaves have interveinal chlorosis; root and top growth greatly retarded	Leaves have interveinal chlorosi	Leaves have bronze-yellow inter veinal mottling chlorotic between veins small; young leaves affected first	Leaves have dull yellow green interveinal chlorosis; fruit pale in color when ripe

7	Molybdenum	Leaf chlorosi imilar to that f nitrogen deficiency; growth reduced		Le ve have marginal and int r-veinal yellow-green mottling; ld leave leathery curled withered especially t tip and margi ; i severe cases shrivel and abscis	Leaves have numerous random, irregular chloroti spot usually 4-12 mm i diameter yellow on uppe sur face brownish on lowe surface; shed prematurely
8	Nitrogen	Leaves yellow; older leave af fected first; roots long and fibrous	Leaves small pal green; older leave pigmented orange red or purpl bed prematurely; peti l s t narrow angl with shoot ; fruit small and highly colored when ripe	Young leave pal green; lde l ves dull purpl margins di ; beads small firm	Leave yellowish green to yellow bed premat rely terminal growth hort spars ; hoots di back
9	Phosphorus	Leaves bluish-green blades may tilt upward; tems usually become reddish-purple; plant spindly growth rate retarded; poor tillering.	Leave small dark green with purpl pigmentation; lde leaves mottled with yellow dark green areas shed prematurely; petioles at narrow angle with shoots; shoot lends purplish; (not cold hardy); fruit bud f rmation reduced; fruit small variable i col r	Leave dull purpl red; head small firm.	Older leaves dull brown green ften with blackened necrotic areas shed prematurely; hoots di back; fruit large coarse acid may drop prematurely
10	Potassium	Leaflets chlorotic as small dots around leaf margins in initial stages later enlarging necrotic margins brown, ragged Older leaves more affected than young leaves	Leaves bl ish green followed by interveinal chlorosi t marginal necrosi ; do not shed readily; shoot growth short; fruit small poorly colored	Leave yellow; severe tipburn f out r leav ; heads usually hard	Le ves small wrinkl i r cu led with marginal scorching; fruit small high in sugar low in acid
11	Sulfur	Similar to nitrogen deficiency; young leaves affected first	Leaves pal green.	Leaves pal yellowish green	Leaves yellow especially younger leaves; shoot di back; immature fruit light green; ripe fruit light orange pulpy sometimes dwarfed mi hapened peel thick
12	Zinc	Leaf margins roll inward chlorotic areas appear along leaf margins or between veins; roots turn brown thicken become stunted and stubby	Spring growth characterized by whorl or rosettes of small stiff mottled leaves; fruit bud formation reduced; fruits small malformed; hoot may di back.		Leave have i t rveinal chlorosis mottl d ppearance small leaves; hoot di back; some fruit small misshapen.

93 SIGNS OF CHEMICAL ELEMENT DEFICIENCY EIGHT SELECTED PLANTS (Section II)

Element / Species	Corn (Zea mays)	Lettuce (Lactuca sativa)	Tobacco (Nicotiana tabacum)	Tomato (Lycopersicon esculentum)
Boron	Newly formed leaves have elongated watery stripes becoming white on drying, growing point necrotic; older leaves have yellowish-white stripes; sterility common; developed ears may show corky brown bands at base of kernels	Terminal leaves puckered curled with necrosis at margins, followed by death of growing point.	Terminal bud leaves light green twisted necrotic at basal portion, followed by death of terminal buds; upper leaves light green, curled stiff brittle vascular tissue with dark discolorations; flowers shed; root poor have many branches	Stem apex becomes yellow then brown followed by death; terminal leaves small twisted chlorotic necrotic; older leaves stiff, brittle become purple; vascular tissue breaks down; roots poorly developed, yellow to brown; fruits frequently have darkened or dried areas
Calcium	Leaf tips of innermost unfolding leaves gelatinized and adhere upon drying.	Young leaves chlorotic wrinkled by restricted growth rosette condition may develop.	Leaves of terminal buds and lateral branches light green, hook downward necrotic at tips and margins, often followed by death of terminal buds; flowers show breaking down of corolla and shed; roots short much branched	Young leaves of terminal growth yellowish brown or purple becoming necrotic; leaf edges curl downward; terminal flowers die; plants weak, lose turgor; roots short much branched stubby brown.
Copper	Plants stunted; leaves pale yellow or reddish yellow	Leaves chlorotic curled; growth stunted; heads soft	Terminal leaves lose turgor followed by permanent wilting gray-green necrosis on older leaves; seed stalk drooping.	Terminal shoots stunted; leaves dark bluish green, curled inward soft, chloroti ; petioles and stems small soft; flower formation absent.
Iron	Young leaves have pale striping becoming more pronounced with alternating dark green and yellow to white stripes extending entire length of leaves; young leaves may be almost white middle leaves with stripes and older leaves with healthy characteristi color		Young leaves have interveinal chlorosis becoming yellowish white including veins; older leaves have healthy characteristic color; roots little branched.	See tobacco.
Magnesium	Older or lower leaves have interveinal and marginal chlorosis producing streaked effect followed by necrosis of chloroti areas.	Older leaves have chlorotic mottling.	Older leaves progressively chloroti , occurring with loss of green in lower leaves at tips margins and interveins; roots long little branched slimy; stalks slender	Older leaves have interveinal chlorosis and necrosis petioles hang downward; stalks slender; roots long with few branches. Brown dead areas appear along the edges of the leaflets in severely affected plants.
Manganese	Leaves have chlorotic streaks more or less continuous from base to tip made up of a chain of chloroti spots with irregular margins Occurs first on young leaves.	Leaves chloroti becoming necrotic.	Young leaves chlorotic with branches of veins green interveins light green to white with reticulated appearance followed by necrosis as small spots over entire leaf	See tobacco

7	Molybdenum		Young leaves chlorotic mottled curled; older leaves have web chlorotic margins veins light green leaf margins shrivel and di	See tomato.	Lower leaves have chlorotic mottling and necrosi margins curl
8	Nitrogen	Young plants stunted leaves yellowish-green; in older plants lower leaves show yellowing and drying at tips and progressing along midveins with margins remaining green finally the entire leaf dies First symptom is general paling of foliage	Leaves pal green; older leaves show yellowing followed by death and drying or firing; heads small and firm.	Leaves erect small light green; older leave lemon to orange-yellow followed by drying to light brown; stalks slender; root long and little branched.	Leaves light green; lower leaves yellow followed by drying veins deep purple; flower buds yellow shed; fruit small firm, highly colored when ripe
9	Phosphorus	Young plant tunted leaves dark green or purplish; stalks slender; maturity delayed which may result in poor pollination and irregular rows of kernels on ear	Leaves dull green, older leaves yellow; small firm heads; growth stunted	Leaves dark green narrow erect; older leaves may become necrotic turning dark brown to black; maturity delayed.	Leaves dark green purple pigmentation on underside; older leaves turn black upon drying
10	Potassium	Leaves yellow to yellow-green streaked corrugated, followed by necrosis of margins and tips more pronounced on older leaves; narrow angle between base of leaf blade; internodes short; tip end of ears poorly filled	Leaves dark green; older leave have marginal interveinal necrosis	Leaves bluish green with brown to rusty necrotic areas cupped at tips and margins; stalks leafier; roots long with few branches slimy	Lower leaves yellowish or grayish green along margins and tips followed by brown necrosi ; stalks slender; fruit soft uneven ripening.
11	Sulfur	General paling of foliage over all of plant; similar to nitrogen deficiency		Younger leaves lighter green than older leaves followed by all leaves becoming light green sometimes with necrosi and blistering; roots abundant much branched.	Leaves pale green underside of veins purple; stems slender stiff woody; roots abundant much branched small in diameter
12	Zinc	Older leaves have whitish chlorotic streaks between veins becoming necrotic; in acute cases plants stunted throughout season and produce no ears; in some cases young leaves in bud white to light yellow Young plants show symptoms before older plants		Lower leaves thick light chlorosis at tips and margins becoming necrotic; internodes shortened	Leaflets small mottled necrotic with midribs shortened.

94 CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT DEFICIENCY

Data represent soil type and pH ranges in which deficiencies of various elements most commonly occur

Element	Factors Promoting Deficiencies			Organisms Serving as Deficiency Indicators[2]
	Soil pH		Soil Type and Other Characteristics	
	Range	Significance[1]		
(A)	(B)	(C)	(D)	(E)
Aluminum[3]	5.5–8.0	High		Hydrangea
Boron	5.0–8.0	Medium to low	Calcareous soils with high calcium-boron ratio frequently on leached acid sandy soils low in organic matter particularly under intensive cropping	Apple; beet; cauliflower kale turnip; celery legumes; tobacco
Calcium	<4.5[4,5]	High	Light sandy soils; highly acid soils	Alfalfa, beet celery clovers flax, peas potato tomato
Cobalt			Availability decreases with increasing pH	Ruminants and other animals feeding on Co-deficient plants
Copper	<5.0; 7.6–8.[illegible]	Medium	Heath soils and peat; acid and calcareous sands and gravels	Cereals; apple; pear; citrus; peach, plum, etc ; flax; various grasses; legumes; lettuce; onion; tomato
Iodine		Low	Areas of calcareous rocks river flats and alluvial soils	Animals feeding on I-deficient plants
Iron	>7.0[6]	Medium to high	Particularly on calcareous soils; may be induced on acid soils by high concentration of heavy metals	Apple; sugar beet; pear; citrus; peach, plum etc ; grape; pineapple; raspberry; strawberry
Magnesium	<5.0	Low	Light acid sandy soils; may be induced by heavy application of potassium and calcium fertilizers	Apple sugar beet cauliflower citrus kale lettuce oats potato tobacco tomato
Manganese	6.5–8.0	High	Soils high in organic matter calcareous soils	Bean beet grasses oats potato tomato, tree and bush fruits (except citrus)
Molybdenum	4.5–6.5	High	Light leached, acid soils	Sugar beet; cauliflower swede kale, Brussels sprouts etc ; citrus; legumes; lettuce; tomato
Nitrogen	<5.5	Low	Particularly light acid soils; of general occurrence	Non-legumes Legumes at low pH (induced by Mo-deficiency)
Phosphorus	<6.0; 7.0–8.0	Medium to high	Particularly acid soils clay and certain calcareous soils	Beet cereals other grasses legumes cotton, potato swede turnip
Potassium	<5.5	Medium	Sandy soils particularly when leached; light calcareous soils	Beet corn, tree and bush fruits legumes potato tobacco tomato tung tree
Sodium	<5.5	High	Sandy inland soils	Beet carrot celery swede turnip[7]
Sulfur	<5.0	Low	Particularly on leached eroded soils of areas remote from urban and industrial districts	Cotton, flax, legumes tea.
Zinc	<4.5; 7.6–8.[illegible]	Medium to low	Soils with high organic matter; leached sands and gravels	Sugar beet cacao cereals citrus and other tree fruits clover flax various grasses potato swede tomato tung tree

/1/ Classified as: high symptoms seldom occur outside the stated pH; medium symptoms occur most commonly within the stated pH; low symptoms occur at all pH values /2/ Species most sensitive to a deficiency state and therefore exhibiting symptoms of deficiency of the element in a short period of time /3/ Data refer to the role of aluminum in producing blue pigments in hydrangea flowers /4/ Reported to be 5.5–6.5 with flax growing on certain waterlogged soils /5/ Reported to be 5.5 on very acid sandy soils which have been treated with magnesium limestone /6/ Reported to be 7 for citrus crops /7/ Sodium is utilized by certain higher plants and is considered an essential element for beets

95 CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT EXCESS

Data represent soil type and pH ranges in which toxicities of various elements most commonly occur

Element	Factors Promoting Toxicities			Organisms Serving as Toxicity Indicators[2]
	Soil pH		Soil Type and Other Characteristics	
	Range	Significance[1]		
(A)	(B)	(C)	(D)	(E)
Aluminum	<5 5	High	Often accompanied by phosphorus deficiency	Barley sugar beet carrot celery, flax leek some var French bean
Arsenic		Low	From continued use of arsenical sprays[3]	Alfalfa apricot barley peach tomato
Boron	<5 5>8..		Light soil irrigated with boron-rich water	Avocado; citrus; blackberry; peach plum, etc ; potato
Cobalt	<5 0		Acid soils with high concentration of heavy metals particularly from industrial effluent	Sugar beet cauliflower tomato
Copper	<5 0		See cobalt	Sugar beet cauliflower tomato
Fluorine	<6 5	High	Areas of industrial pollution	Barley buckwheat collards tomato
Lithium	>8.2		Certain irrigated soils	Citrus corn tomato wheat
Manganese	<5 5	High	General occurrence Often in rather impervious mineral soils	Alfalfa, barley kale lespedeza potato swede sweetclover tomato vetch
Molybdenum	7 0-7 5	High	Soils derived from rocks high in molybdenum content	Ruminants feeding on Mo-rich plants[4]
Nickel	<6		Availability decreases with increasing soil pH	Beet cabbage kale turnip clover oats potato tomato
Selenium			Soils derived from Upper Cretaceous rocks (in America) and Upper Carboniferous Limestone (in Ireland)	Animals feeding on Se rich plants
Zinc	<5 0		See cobalt	Sugar beet cauliflower tomato

/1/ Classified as: high = symptoms seldom occur outside the stated pH; medium = symptoms occur most commonly within the stated pH; low = symptoms occur at all pH values /2/ Species most sensitive to a toxicity state and therefore exhibiting symptoms of excess of the given element in a short period of time /3/ Reported to occur in oats from the presence of minerals containing arsenic in the soil /4/ Inconsistent results with field plants

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen nitrogen oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates fats and other organic compounds and for formation of end products of bacterial metabolism.

Bacteria (A)	Elements (B)	Essential Function or Role (C)
Heterotrophic Bacteria[1]		
Aerobacter aerogenes	Fe	Needed for growth
	Mg Mn	In the enzyme system transforming pyruvate to acetylmethyl carbinol
	Cr or Mn (partially replaceable by Al, Cu, Fe Zn)	Required for normal fermentation
Aerobacter indologenes	Fe	In hydrogenase, formic dehydrogenase, formic hydrogenlyase, and cytochrome.
Azotobacter spp	Fe	Needed for growth
	Ca (replaceable by Sr)	Required for nitrogen fixation
	Mo (partially replaceable by V)	Required for nitrogen fixation.
	Co, Mg, Mn, Zn	In oxalacetate decarboxylase
Bacillus anthracis	Ca, Fe K, Mg Mn	Needed for growth.
Bacillus cereus	K	Needed for spore formation
Bacillus subtilis	Fe K, Mg Mn, Zn	Needed for growth and production of subtilin (antibiotic)
Brucella abortus	Mg or Mn	Needed for normal growth of the antigenic nonsmooth variants
Brucella suis	Fe Mg Mn	Needed for growth
Cellulomonas spp	Mg	Needed for growth
Clostridium acetobutylicum	Fe	Required for normal fermentation
	Mn Zn	In phosphatase
	Mo (partially replaceable by V)	Required for nitrogen fixation
Clostridium botulinum	Fe	In polypeptidase
Clostridium butyricum	Mo (partially replaceable by V)	Required for nitrogen fixation.
Clostridium histolyticum	Fe	In polypeptidase
Clostridium perfringens	Mg	Necessary for cell division
	Fe	Needed for no[illegible] fermentation
Corynebacterium diphtheriae	Fe	Needed for gr[illegible] formation of toxin and por[illegible]
Escherichia coli	Fe	Needed for [illegible]
	Mg Mn	[illegible] pyruvic [illegible]
	Mg, Mn	[illegible] enolase
Hemophilus influenzae	Fe	[illegible] of the [illegible] hemin

/1/ Utilize organic materials such as sugars [illegible] amino [illegible] source of carbon for energ[illegible]

96 FUNCTIONS OF ESSENTIAL ELEMENTS BACTERIA (Continued)

The functions listed in the table require the specific elements noted. In addition, carbon hydrogen nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of bacterial metabolism.

Bacteria	Elements	Essential Function or Role
(A)	(B)	(C)
Heterotrophic Bacteria[1] (concluded)		
Klebsiella pneumoniae	Fe	Needed for growth
Lactobacillus arabinosus	Mn	Needed for growth
	K	Needed for growth
Lactobacillus casei	Mn	Needed for growth
	K	Needed for growth
Lactobacillus lactis	Co	Part of the growth factor vitamin B_{12}
Lactobacillus leichmanii	Co	Part of the growth factor vitamin B_{12}
Leuconostoc mesenteroides	K, Mn, P	Needed for growth
Propinonibacterium jensenii	Mg, Zn	In phosphatase
Pseudomonas aeruginosa	Fe, S	Needed for production of pyocyanine (antibiotic)
	Mg, P, S	Needed for production of fluorescent pigment
	Fe	In cytochrome, cytochrome oxidase catalase and peroxidase
	Mg	Needed for growth.
Pseudomonas spp	B Ca, Co Cu, Fe Mn, Mo Zn	Needed for growth
Serratia marcescens	Fe, Mg	Needed for pigment formation
Sporocytophaga myxococcoides	Fe, Mg	Needed for growth and decomposition of cellulose
Streptococcus faecalis	K, Mn, P	Needed for growth
Misc unidentified bacteria	Ca Mg	In protease
	Zn	In polypeptidase
Photosynthetic Bacteria[2]		
All photosynthetic bacteria	Mg	Part of bacteriochlorophyll
Athiorhodaceae (nonsulfur purple bacteria)	B, Ca, Cu, Fe Ga Mn Zn	Needed for growth
Thiorhodaceae (sulfur purple bacteria)	S required in the form of sulfide sulfite thiosulfate	Indispensable reducing agent for photosynthesis
Sulfur green bacteria	S required in the form of sulfide	Indispensable reducing agent for photosynthesis

/1/ Utilize organic materials such as sugars, fatty acids amino acids alcohols, etc as source of carbon for energy and growth. /2/ Capable of growing on CO_2 as the sole source of carbon by utilizing light energy

96 FUNCTIONS OF ESSENTIAL ELEMENTS BACTERIA (Concluded)

The functions listed in the table require the specific elements noted. In addition carbon, hydrogen nitrogen oxygen phosphorus and sulfur are required for the functions of synthesis of structural proteins carbohydrates, fats and other organic compounds, and for formation of end products of bacterial metabolism.

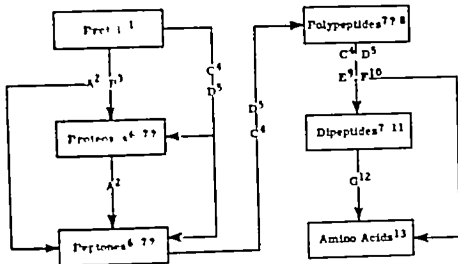
Bacteria (A)	Elements (B)	Essential Function or Role (C)
Chemoautotrophic Bacteria[3]		
Hydrogenomonas species	H	Molecular hydrogen oxidized as the source of energy
Nitrifying bacteria	Cu	Needed for nitrification (oxidation of ammonia and nitrite)
Nitrosomonas species (ammonia-oxidizing nitrifiers)	N in the form of ammonia	Indispensable as the substrate oxidized to provide energy
Nitrobacter species (nitrite-oxidizing nitrifiers)	N in the form of nitrite	Indispensable as the substrate oxidized to provide energy
Thiobacillus species (sulfur-oxidizers all aerobic)	S in reduced form such as S sulfide, thiosulfate	The substrate oxidized to provide energy
Thiobacillus denitrificans (sulfur-oxidizer, anaerobic)	Reduced sulfur (as above)	The substrate oxidized to provide energy
	N in the form of nitrate	Indispensable as the oxidizing agent
Sporovibrio desulfuricans (sulfate-reducer)	S in the form of sulfate	Indispensable as the oxidizing agent
Clostridium aceticum	H	Molecular hydrogen oxidized as the source of energy
	CO_2	Employed as oxidizing agent
Methanobacterium omelianski	H	Molecular H oxidized as the source of energy
	CO_2	Employed as oxidizing agent
Iron bacteria	Fe Mn	The substrates oxidized to provide energy

/3/ Capable of growing with CO_2 as the sole source of carbon and with energy derived from th oxidation of inorganic materials A few of these organisms grow only autotrophically but mos of them can develop either as heterotrophs or as autotrophs

97 CHEMICAL CHANGES IN PROTEIN DIGESTION AND ABSORPTION MAN, LABORATORY MAMMALS

Protein digestion, i[illegible] the aliment[illegible]y canal comprises the enzymatic cleavage of the protein molecule in-
to its component amino aci[illegible] which are absorbed into the blood stream Although the diagram is a summary
of present knowledge of the fi[illegible]ld controversy still exists with regard to some of the details

A = Pepsin; B = Rennin; C = Trypsin; D = Chymotrypsin; E = Carboxypolypeptidase; F = Aminopolypeptidase;
G = Dipeptidase

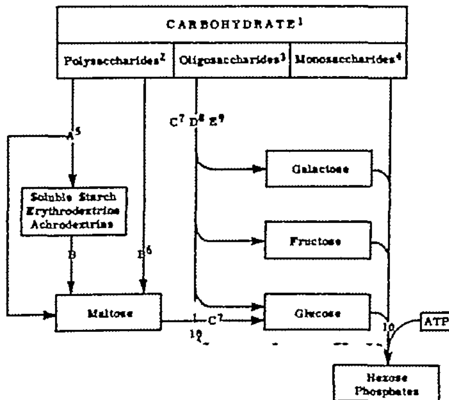


/1/ Native denatured or coagulated / /2/ Secreted by the gastric mucosa as pepsinogen; activated by HCl
Pepsin is an autocatalytic endopeptidase hydrolyzing peptide bonds in the interior of the protein molecule
/3/ In gastric juice of the young of some mammals, but probably not the adults; converts soluble calcium
caseinate to insoluble calcium paracaseinate (clot) /4/ Secreted in pancreatic juice as trypsinogen; acti
vated by enterokinase Trypsin is an autocatalytic endopeptidase hydrolyzing native proteins to proteoses
peptones and polypeptides by splitting peptide bonds involving a basic nitrogen (as in lysine arginine)
/5/ Secreted in pancreatic juice as chymotrypsinogen; activated by trypsin Chymotrypsin is an endopeptidase
hydrolyzing native proteins to proteoses peptones and polypeptides by splitting peptide bonds involving an
aromatic group (as in tyrosine phenylalanine) /6/ Secondary protein derivatives of molecular weight less
than 1000 exclusive of polypeptides and simpler degradation products /7/ Some absorption /8/ A compound
containing more than two amino acids joined by peptide linkages /9/ One of several exopeptidases (called
erepsin) in pancreatic juice removing successively amino acids with free carboxyl groups from the end of the
peptide chain, thus hydrolyzing polypeptides to simpler peptides and amino acids /10/ Secreted by intesti
nal mucosa in succus entericus; an exopeptidase removing successively amino acids with free amino groups
from the end of the peptide chain thus hydrolyzing polypeptides to simpler peptides and amino acids /11/
Dipeptides contain two amino acids /12/ Secreted by intestinal mucosa in succus entericus; hydrolyzes di
peptides to amino acids by breaking the peptide linkage /13/ Absorbed

98 CHEMICAL CHANGES IN CARBOHYDRATE DIGESTION AND ABSORPTION MAN, LABORATORY MAMMALS

Carbohydrate digestion is the enzymatic hydrolysis of poly- and oligosaccharides into their monosaccharide components which are then absorbed into the blood stream. Monosaccharides are phosphorylated to hexose-6-PO_4 as they enter the intestinal mucosa and then dephosphorylated before they enter the blood stream.

A = Salivary amylase (ptyalin); B = Pancreatic amylase (amylopsin); C = Maltase; D = Sucrase (invertase); E = Lactase

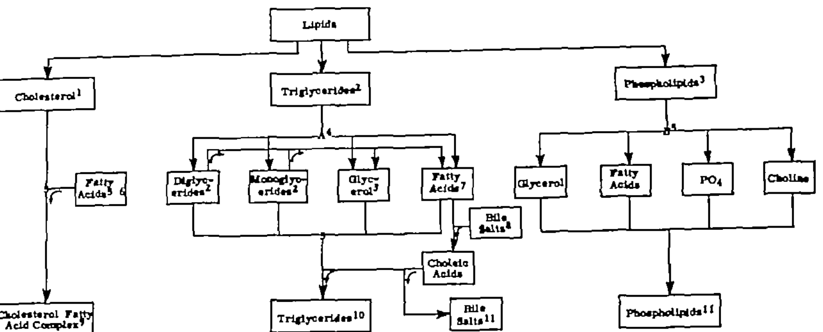


/1/ Ingested /2/ Polysaccharides including glycogen, starch dextrins and cellulose are made up of many monosaccharide (simple sugar) molecules. Cellulose although made up of glucose molecules is not digestible by mammals /3/ Oligosaccharides are carbohydrates composed of only a few (down to two in the case of disaccharides) molecules of monosaccharide. Sucrose contains glucose and fructose; maltose is composed of two molecules of glucose; and lactose contains glucose and galactose as constituents /4/ Ingested monosaccharides are absorbed into the blood stream without breakdown /5/ Salivary amylase not only converts polysaccharides to soluble starch, etc but also breaks off some maltose /6/ Pancreatic amylase but not salivary amylase will hydrolyze uncooked starch only to an insignificant extent /7/ Maltase in intestinal secretion, hydrolyzes each molecule of maltose to two molecules of glucose /8/ Sucrase in intestinal secretion hydrolyzes sucrose to glucose and fructose /9/ Lactase in intestinal secretion hydrolyzes lactose to glucose and galactose /10/ Possibly other hexoses

99 CHEMICAL CHANGES IN LIPID DIGESTION AND ABSORPTION MAN LABORATORY MAMMALS

Details of digestion and absorption of lipids are not as well established as those for protein and carbohydrate. The pathways as presented may be expected to undergo some modification with further research in the field.

A Pancreatic lipase (steapsin); B Lecithinase



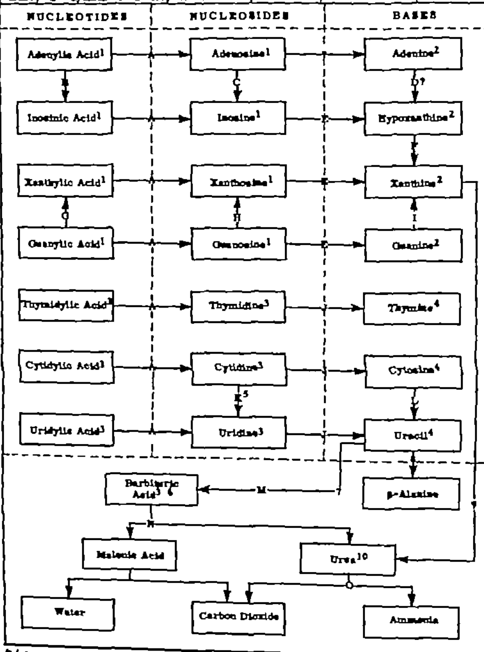
/1/ Absorbed in the presence of fat (except in rabbits); excess cholesterol may hinder fat absorption. Some conversion to coprosterol by intestinal bacteria and excreted as such. Plant sterols are not absorbed? /2/ Tri, di and monoglycerides = compounds of glycerol and 3 or 2 or 1 molecule fatty acid. Some absorption? /3/ Absorbed. Include ( ) lecithins (glycerol + fatty acids + phosphoric acid + choline) (b) cephalins (+ glycerol + fatty acids + phosphoric acid + cholamine or serine or inositol) and (c) sphingomyelins (+ fatty acid + phosphoric acid + choline + sphingosine) /4/ In intestinal lumen. /5/ In intestinal mucosa. /6/ From hydrolysis of glycerides or phospholipids /7/ Short-chain (1 10 carbon or less) fatty acids being water soluble are readily absorbed into the intestinal mucosa; long chain fatty acids absorbed with the aid of bile salts (q v) /8/ In addition to forming choleic acid complexes with fatty acids bile salts serve as emulsifying agent to hasten absorption of lipid digestion end products /9/ Absorbed into lymphatic system. /10/ Mono- and diglycerides and fatty acids and glycerol (from triglyceride or phospholipid hydrolysis) recombine in the intestinal mucosa to form triglycerides of different composition from those ingested. Those containing short-chain fatty acids are absorbed chiefly into the portal blood stream; the more insoluble fats containing long-chain fatty acids are absorbed through the lacteals into the lymphatic system. /11/ Absorbed into portal blood.

	Amino Acid (A)	Product of Oxidative Deamination or Transamination (B)	Product of Decarboxylation (C)	Pathways and Products of Metabolism (D)
1	L-Alanine	Pyruvic acid		
2	L-Arginine	α-Keto-δ-guanidovaleric acid	Agmatine	Arginine ⟶ ornithine urea Arginine ⟶ citrulline + NH_3
3	L-Asparagine	α-Ketosuccinamic acid		Asparagine ⇌ aspartic acid + NH_3
4	L-Aspartic acid	Oxalaceti acid	α-Alanine β-Alanine	Aspartic acid ⇌ fumari acid + NH_3; malic acid suc- other products include cinic acid propionic acid
5	L-Citrulline	α-Keto-δ-carbamidovaleric acid		Citrulline + NH_3 ⟶ arginine Citrulline ⟶ ornithine CO_2 + NH_3
6	L-Cysteine	β-Mercapto-pyruvic acid		Cysteine sulfenic acid ⟶ cyst ine sulfin- ic acid ⟶ cysteic acid ⟶ taurine; cysteine ⟶ H_2S NH_3 + pyruvic acid
7	L-Glutamic acid	α-Ketoglutaric acid	γ-Aminobutyric acid	See ornithine proline histidine glutamine
8	L-Glutamine	α-Ketoglutaramic acid		Glutamine ⇌ glutamic acid + NH_3
9	Glycine	Glyoxylic acid		Glycine ⇌ formate ⇌ serine NH_3
10	L-Histidine	β-Imidazolepyruvic acid	Histamine	Histidine ⟶ urocanic acid ⟶ glutamic acid
11	L-Hydroxyproline	α-Keto-γ-hydroxy-δ-aminovaleric acid		See proline
12	L-Isoleucine	D-α-Keto-β-methylvaleric acid		α-Keto-β-methylvaleric acid ⟶ α-methyl butyric acid ⟶ 2 and 3- carbon frag- ments
13	L-Leucine	α-Ketoisocaproi acid		α-Ketoisocaproi acid ⟶ isovaleri acid ⟶ acetoacetic acid
14	L Lysine	α-Keto-ε-aminocaproi acid	Cadaverine	Lysine ⟶ α-aminoadipic acid ⟶ glutari acid; α-ketoadipic acid ⟶ dehydro- α-keto-ε-aminocaproi acid ⟶ pipecolic acid picolini acid ⟶
15	L-Methionine	α-Keto-γ-methiolbutyri acid		Methionine ⟶ homocysteine ⟶ (a) α-keto- homocystei acid; (b) H_2S NH_3 cysta- butyric acid; ( ) + serine ⟶ homoserine thionine ⟶ cysteine + homoserine
16	L-Ornithine	α-Keto-δ-aminovaleric acid	Putrescine	Ornithine NH_3 + CO_2 ⟶ citrulline
17	L-Phenylalanine	Phenylpyruvi acid	Phenylethylamine	Phenylalanine ⟶ (a) tyrosine (b) phenyl pyruvi acid ⟶ phenylacetic and phenyllacti acids
18	L-Proline	α-Keto-δ-aminovaleri acid		Proline ⟶ (a) ornithine; (b) glutamic acid; ( ) hydroxyproline
19	L-Serine	β-Hydroxypyruvi acid		Serine ⟶ NH_3 pyruvic acid; serine indol ⟶ tryptophan; see glycine
20	L-Threonine	α-Keto-β-hydroxybutyric acid		Threonine ⟶ NH_3 + α-ketobutyric acid
21	L-Tryptophan	β-Indolepyruvi acid	Tryptamine	Tryptophan ⟶ formylkynurenine ⟶ kynurenine ⟶ (a) kynurenic acid (b) alanine ( ) 3-hydroxy- anthranili acid kynurenine ⟶ 3-hydroxyanthranilic acid ⟶ nicotini acid
22	L-Tyrosine	Para-hydroxyphenylpyruvi acid	Tyramine	Para-hydroxyphenylpyruvic acid ⟶ homogen- ti ic acid ⟶ fumarylacetoaceti acid ⟶ fumaric acid + acetoacetic acid
23	L-Valine	α-Ketoisovaleri acid		α-Ketoisovaleric acid ⟶ isobutyric acid ⟶ 3 carbon fragment + CO_2

101 PATHWAYS OF PURINE AND PYRIMIDINE NUCLEOTIDE CATABOLISM

Nucleotides are composed of a purine or pyrimidine base linked to a pentose or desoxypentose sugar which, in turn, is linked to phosphate. Removal of the phosphate leaves a compound designated as a nucleoside. See table 102 for pathways of nucleoprotein metabolism in general.

A Phosphatase; B Adenylic acid deaminase; C Adenosine deaminase; D Adenase?; E Nucleoside phosphorylase; F Xanthine oxidase; G Guanylic acid deaminase; H Guanosine deaminase; I Guanase; J Phosphorylase or hydrolase; K = Cytidine deaminase; L Cytosine deaminase; M Uracil-thymine oxidase; N Barbiturase; O Urease



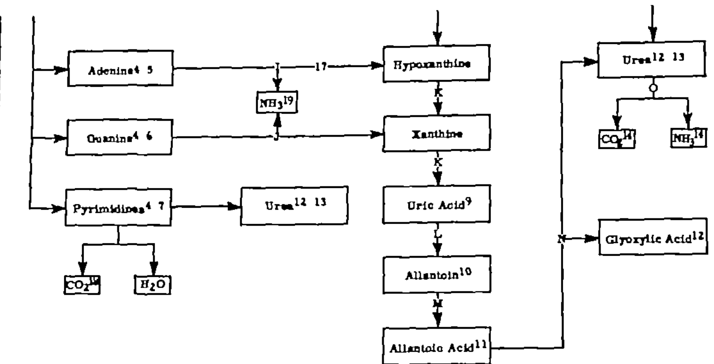
/1/ A purine derivative or contains purine ring. /2/ A purine /3/ A pyrimidine derivative or contains pyrimidine ring. /4/ A pyrimidine /5/ Demonstrated in yeast and E coli /6/ Thymine yields 5-methyl barbituric acid. /7/ Pathway demonstrated with Corynebacterium and Mycobacterium. /8/ In animal tissues; methyl uracil (thymine) yields β-aminoisobutyric acid. /9/ via: uric acid, allantoic acid, and glyoxylic acid. (cf table 102) /10/ Urea is excreted as the end product of amino acid metabolism by mammals and as an end product of purine and pyrimidine metabolism by most fishes amphibia and fresh water lamellibranchs

102 PATHWAYS OF NUCLEOPROTEIN CATABOLISM

Nucleoproteins generally are composed of basic proteins histones or protamins, associated with nucleic acids The nucleic acids are complex molecules each composed of many nucleotide units joined by phosphate sugar linkages Each nucleotide is made up of a purine or pyrimidine base linked to a pentose or desoxypentose and this in turn to a molecule of phosphoric acid Upon hydrolysis of the nucleotide in the digestive tract or tissues the phosphoric acid is removed The remaining compound, a nucleoside contains the purine or pyrimidine base and the sugar residue

A = Nucleoproteinase
B = Nucleodepolymerase
C = Polynucleotidase
D = Nucleotidase
D = Adenylic acid deaminase
E = Phosphatase
F = Nucleoside phosphorylase
G = Nucleoside phosphorylase in mammals; hydrolase in some microorganisms
H = Nucleosidase
I = Adenase
J = Guanase
K = Xanthineoxidase
L = Uricase
M = Allantoinase
N = Allantoicase
O = Urease
P = Proteases
Q = Decarboxylase
Q = Amine oxidase
R = Arginase
S = Arginase
T = Amino acid deaminase

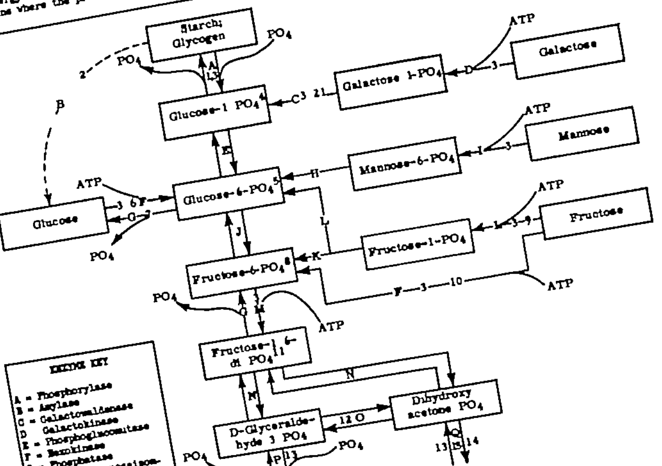
Nucleoprotein[1]
Proteins[1]
Amino Acids
Nucleic Acids[1]
Polynucleotides
Nucleotides[2]
NH_3[19]
Inosinic Acid
-PO_4
Inosine
Nucleosides[3]
Pentose or Desoxypentose[8]
CO_2[18]
Amines
NH_3[19]
ORNITHINE CYCLE[15]
Keto Acids (Carbon Rests)
16
CO_2
H_2O

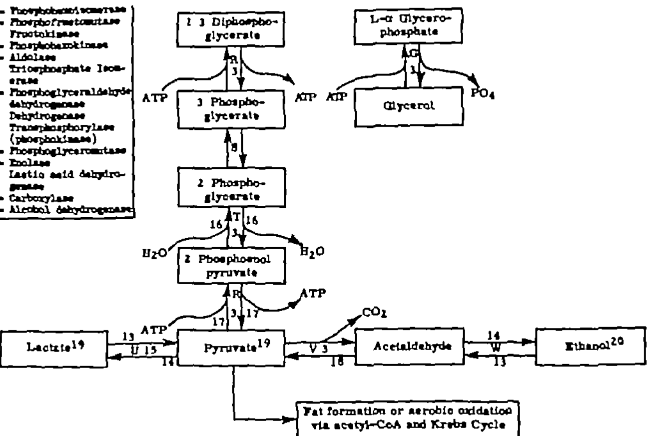


/1/ Catabolism of nucleoprotein, nucleic acid, and protein may take place in the alimentary canal or in the tissues See table 101 for detailed pathways of purine and pyrimidine nucleotide catabolism. /2/ Some intestinal absorption Nucleotidase in liver splits both pyrimidine and purine nucleotides to nucleosides /3/ Absorbed in the intestine Purine nucleosides are split into purines and pentoses by purine nucleosidase present in tissues /4/ Mammals do not require exogenous purines or pyrimidines but can synthesize them from products of protein metabolism. /5/ Adenine and guanine are the only naturally occurring purines in nucleic acids /6/ Excreted by pig and spider /7/ Little is known about the stages in pyrimidine catabolism. It is thought that pyrimidine nitrogen is largely converted to urea indicating disruption and metabolism of the pyrimidine ring (cf table 101) /8/ D-Ribose and D-2-desoxyribose have been definitely stablished as present in nucleoproteins; other pentoses may be present. /9/ Excreted as end product of purine catabolism by primates Dalmatian dog some reptiles some insects;and as end product of catabolism of proteins as well as purines and pyrimidines by birds (no urea formation by birds) /10/ Excreted by most mammals gastropods and some insects /11/ Excreted by some teleost fishes /12/ Excreted by most fishes amphibia fresh water lamellibranchs /13/ Urea is excreted as the end product of amino acid metabolism by mammals and as an end product of purine (and pyrimidine?) metabolism by some other forms (cf Fn 12) /14/Crustacea, gephyrean worms marine lamellibranchs do not excrete urea but break it down to CO_2 and NH_3 which are excreted./15/Urea formation in the mammalian liver is via the Ornithine Cycle" (Krebs-Henseleit Cycle") The pathway through the cycle is: ornithine ⟶ citrulline⟶ arginine succinate ⟶ arginine ⟶ ornithine CO_2 and NH_3 enter the cycle at ornithine,NH_3 and aspartic acid at citrulline Arginine succinate is split to arginine and fumaric acid after which arginine is converted to ornithine with the release of urea. /16/ Via Krebs Cycle (cf table 106) In the course of amino acid metabolism previous to entry into the Krebs Cycle sulfur-containing amino acids lose their sulfur usually in the form of SO_4 /17/ There is little likelihood that the route adenine ⟶ hypoxanthine is of any importance in animals Adenase is not found to any extent in mammals /18/ May enter into metabolic processes into the Ornithine Cycle and be incorporated into and excreted as urea,or be excreted as such /19/May be built into amino acids incorporated into urea and excreted or excreted as such across the kidney tubule(in appropriate animal species)

103 PATHWAYS OF CARBOHYDRATE METABOLISM GLYCOLYSIS

The pathway from stored or ingested carbohydrate to pyruvate is one of release of stored energy by anaerobic oxidation (glycolysis). Released energy is partly dissipated as heat and partly stored (temporarily) in the labile energy pool as high energy phosphate ($\sim PO_4$) by combination of $\sim PO_4$ with continuously available ADP (adenosine diphosphate) to form ATP (adenosine triphosphate). In the conversion of 1 mole of glucose (180 g) or of other monosaccharide to 2 moles of pyruvate (174 g), 2 moles of ATP are converted to ADP and 4 moles are formed from ADP, making a net gain of 2 moles of ATP, equivalent to 24 kilocalories of readily available energy. If glucose-6-PO_4 has come from metabolic breakdown of glycogen, the cost is only 1 mole of ATP, making a net gain of 3 moles of ATP (36 kilocalories). The ATP is an immediate source of energy whose utilization (e g for muscular activity) is independent of oxygen supply. Aerobic oxidation (to carbon dioxide and water) begins where the present pathway ends, and yields an additional 650 kilocalories, per mole of hexose (cf table 106, The Krebs Cycle).

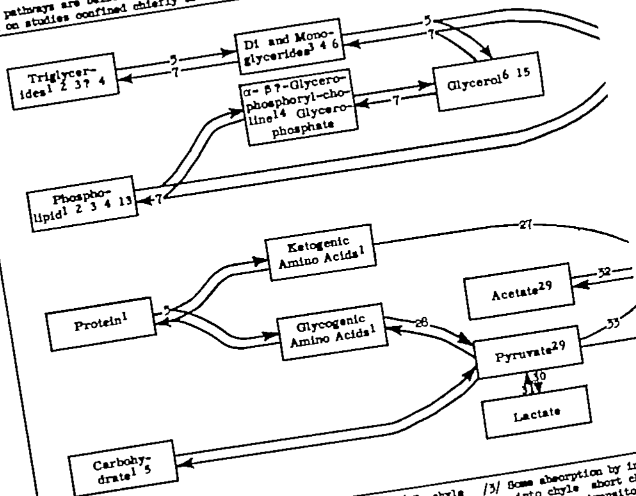




/1/ Adenylic acid and PO_4 required for activity in either direction /2/ Digestion; glycogen and/or starch hydrolysed to glucose in intestinal lumen /3/ Mg^{++} required for this reaction. /4/ "Cori Ester" /5/ "Robison Ester" /6/ "Hexokinase reaction " inhibited by growth hormone plus adrenal cortex hormone; and inhibition by these substances blocked by insulin, which thus favors conversion of glucose to glucose-6-phosphate /7/ The reaction; glycogen to glucose-6-PO_4 to blood glucose takes place in liver only; conversion of glucose to glucose-6-PO_4 to glycogen takes place in liver muscle and other tissues /8/ "Neuberg Ester /9/ In liver and muscle /10/ In all tissue /11/ "Harden-Young Ester" /12/ This reaction (to left) causes each step in the conversion to pyruvate to be doubled quantitatively; thus 1 mole of glucose gives rise to 2 moles of pyruvate /13/ Hydrogen ions released /14/ Hydrogen enters into the reaction /15/ DPN acts as acceptor of released hydrogen ions becoming $DPNH_2$, in oxidative direction of the reaction; $DPNH_2$ gives up hydrogen ions becomes DPN in reverse direction Hydrogen ions accepted by DPN passed on in turn to flavoprotein, cytochrome-c, cytochrome oxidase molecular O_2 If molecular O_2 not sufficiently available hydrogen ions may be passed from $DPNH_2$ to pyruvate forming lactate /16/ Inhibited by fluoride /17/ K^+ also required /18/ Thiamine pyrophosphate is required as coenzyme /19/ Pyruvate followed by conversion to lactate when oxygen supply is deficient (cf Fn 15) ends glycolysis in animal tissues If oxygen is available pyruvate is oxidized via the Krebs Cycle q v /20/ End of fermentation plant tissue /21/ Uridine diphosphate glucose required as coenzyme /22/ Inhibited by iodoacetate

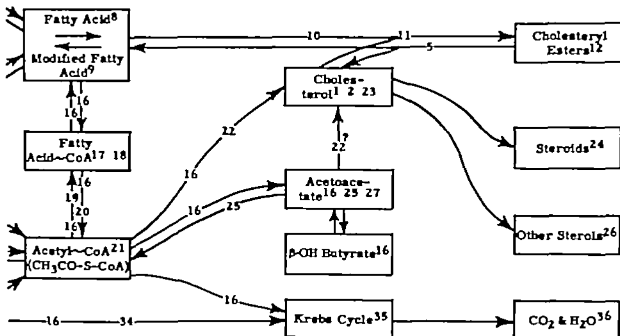
104 PATHWAYS OF LIPID METABOLISM MAMMALS

These pathways are believed to occur in the lipid metabolism of animal forms in general They are based on studies confined chiefly to mammals



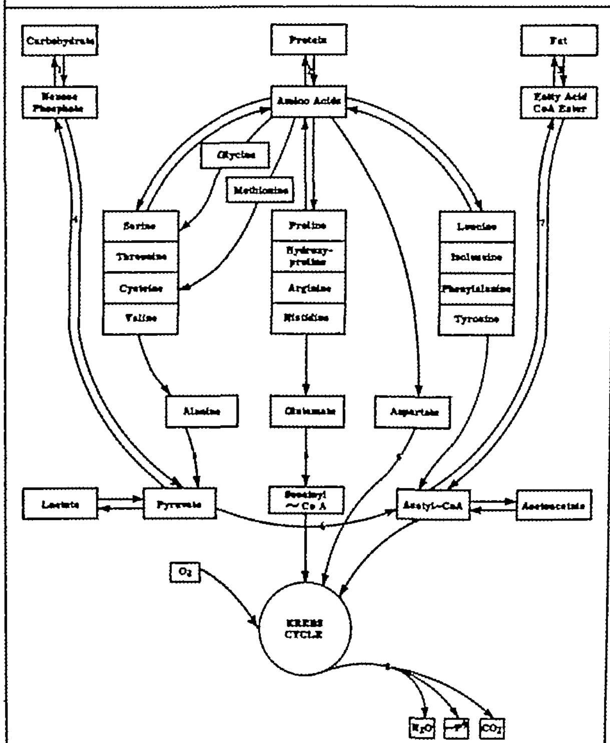
/1/ In intestinal lumen blood liver other tissues /2/ In chyle /3/ Some absorption by intestinal mucosa. /4/ Formed in intestinal mucosa or absorbed from lumen pass into chyle short chains possibly also into portal blood /5/ Digestion in intestinal lumen. /6/ Probably transitory in tissues /7/ In intestinal mucosa, liver other tissues /8/ Occur free (ionized) in intestinal lumen blood liver; free existence in chyle questioned; free existence probably transitory in other tissues if it occurs /9/ In liver carbon chains lengthened or shortened (cf Fn 20) and H added to Co-10 or removed creating double bonds /10/ Chiefly (?) unsaturated /11/ Synthesis probably in intestinal mucosa liver blood /12/ In chyle blood and small amounts in liver, other tissues; not in brain red cells /13/ Chiefly lecithin cephaline (phosphatides of ethanol amine serine inositol acetal and polyglyceride phosphatides) some sphingomyelin. /14/ In intestinal mucosa liver (?) other tissues (?) Split to choline glycerol phosphoric acid /15/ In intestinal lumen absorbed by intestinal mucosa where resynthesized into glycerides, including phospholipids Metabolized to pyruvate /16/ In liver other tissues /17/ Fatty acid ester of coenzyme A i e acyl~CoA ester formed by ATP-dependent acylation of CoA or by transfer of CoA from succinyl or other CoA ester /18/ Coenzyme A probably = pantetheine (pantothenic acid + β-alanine + thioethanolamine) + ADP with a third PO_4 at C_3 of the ribose; forms fatty acid thiol esters via the SH in the thioethanolamine /19/ Reverse of β-oxidation (cf Fn 20) Retarded or

These pathways are believed to occur in the lipid metabolism of animal forms in general. They are based on studies confined chiefly to mammals



blocked in diabetes mellitus starvation (?) Insulin useful probably necessary but site of lipogenic action not known — possibly the hexokinase reaction in carbohydrate metabolism. /20/ Fatty acid-CoA ester shortened 2 carbons at a time by β-oxidation, breaking off a molecule of acetyl~CoA at each step and re-esterifying the remainder with CoA. /21/ Acetic acid ester of coenzyme A known also as S-acetyl coenzyme A, active acetyl. /22/ Via squalene? /23/ Adrenal steroids (C_{11}oxy) promote synthesis (?) /24/ Hormones bile acids /25/ Transported from liver via blood to other tissues where oxidized via acetyl~CoA and Krebs Cycle to CO_2 and H_2O Some conversion to acetone /26/ Coprosterol epicoprosterol excreted. /27/ Tyrosine leucine isoleucine also converted directly to acetoacetate /28/ Aspartate enters Krebs Cycle not via pyruvate but by conversion directly to oxalacetate /29/ Occurs in blood, liver muscle other tissues /30/ Occurs in muscle especially in exercise the lactate diffusing into the blood stream. /31/ Occurs in liver muscle brain, other tissues /32/ ATP-dependent reaction with CoA. /33/ Diphosphothiamine (= cocarboxylase) lipoic acid Mg^{++} required /34/ Pyruvate + CO_2 → oxalacetate malate components of Krebs Cycle Oxalacetate condenses with acetyl~CoA, to form citrate This removal of acetyl~CoA by oxalacetate (i e , by pyruvate) occurring when acetyl~CoA is being formed in active fat catabolism, may explain antiketogenic action of carbohydrate (and protein) /35/ For Krebs Cycle see table 106 /36/ And energy liberation

105 METABOLIC INTERRELATIONSHIPS: CARBOHYDRATE FAT AND PROTEIN



/1/ Phosphorylase and Pi, phosphorylate hexose units in stored polysaccharides; hexokinase and ATP phosphorylate hexoses /2/ Proteolysis by proteases in digestive tract or tissues. Synthesis by proteases of tissues /3/ Lipase splits fat into fatty acids and glycerol; glycerol via glycerol phosphate and dihydroxy acetone phosphate, enters the glycolytic cycle. Fatty acid then is acted upon by coenzyme A. /4/ Glycolysis /5/ Oxidative deamination. /6/ Decarboxylation. /7/ β-oxidation. /8/ Chain of electron-transmitting enzymes /9/ "High energy" phosphorus

106 THE KREBS CYCLE

The Krebs Cycle (tricarboxylic acid cycle) is a major pathway for the final (aerobic) oxidation of carbohydrates, fats, and proteins. These three nutrients are channeled into the cycle via their two key metabolites, pyruvate and acetyl-CoA ("active acetate"). Each "revolution" of the cycle oxidizes 1 mole (59 g) of acetate to CO_2 and H_2O, with release of approximately 200 kilocalories of energy. A portion of the released energy (approximately 144 kilocalories) enters the phosphate energy pool as ATP. Twelve moles of ATP are formed from ADP and PO_4 (by energizing PO_4 to $\sim PO_4$). The remainder of the released energy appears as heat. Oxidation of 1 mole (87 g) of pyruvate proceeding via acetyl-CoA contributes a total of 15 moles of ATP to the energy pool.

A Pyruvic decarboxylase; B Malic enzyme; C Transaminase; D Condensing enzyme; E Aconitase; F Isocitric dehydrogenase; G Oxalosuccinic carboxylase; H α-Ketoglutaric dehydrogenase; I Succinic dehydrogenase; J Fumarase; K Malic dehydrogenase; L Oxaloacetic decarboxylase

/1/ Glucogenic amino acid precursors for pyruvate are: alanine, glycine, serine, threonine, methionine, cysteine, valine. /2/ Ketogenic amino acid precursors for acetyl-CoA are: leucine, isoleucine, phenylalanine, tyrosine. /3/ Aspartic acid occurs as a component of protein. /4/ Glutamic acid occurs as a component of protein or may be formed from: arginine, proline, hydroxyproline, histidine, ornithine. /5/ Coenzyme-A (ADP-pantoyl-β-alanyl-thioethanolamine) and α-lipoic acid required. /6/ In the oxidative direction, DPN (diphosphopyridine nucleotide, a compound of nicotinamide, D-ribose, H_3PO_4, and adenine; also known as coenzyme I) acts as hydrogen acceptor; in the reverse direction $DPNH_2$ is hydrogen donor. /7/ In the oxidative direction, TPN (triphosphopyridine nucleotide; coenzyme II) acts as hydrogen acceptor; in the reverse direction, $TPNH_2$ is hydrogen donor. /8/ DPT (diphosphothiamine; thiamine pyrophosphate; cocarboxylase) required as coenzyme for the carboxylase (A); also Mg^{++} or Mn^{++} is required as activator for the enzyme. /9/ Biotin required as coenzyme for decarboxylation. /10/ 2H enters into the reaction. /11/ 2H released and their electrons transferred to cytochrome. /12/ Hydrogen ions transferred to DPN (or in the case of isocitrate → oxalosuccinate to TPN) and pass in turn to flavoprotein, cytochrome-c, cytochrome oxidase, and finally to combination with molecular oxygen. For each H thus passed and finally oxidized, 1.5 moles of ATP are formed by the addition of energized phosphate ($\sim PO_4$) to ADP. /13/ CO_2 enters into the reaction. /14/ CO_2 released. /15/ H_2O enters into the reaction. /16/ H_2O released. /17/ NH_2 enters into the reaction by transamination. /18/ NH_2 transferred from glutamate by transamination then enters into Krebs Cycle via succinyl ~ CoA. /19/ Footnotes 5, 6, 8, 12, 14 apply to this reaction. /20/ For details of cytochrome system, see table 108.

107 ACTIVITY-METABOLISM MUSCLE

Excitation of the muscle (cell) i accompanied by reversal of polari y of the cell membrane. The first identifiable metaboli event to follow i dephosphorylation of ATP. The breaking off of the terminal PO_4 of ATP is accompanied by release of energy previously stored in the molecule. The compound, minus one phosphate is left as ADP. This compound i an acceptor of phosphate to form "high energy" carrie If the presence of such acceptor i viewed as the stimulus to the subsequent steps activi y metabolism, the presence of ADP causes progression of glucose-1-PO_4 to pyruvate (or to lactate if $DPNH_2$ has accumulated due to inadequacy of O_2 supply) and also brings about the progression of pyruvate to CO_2 and H_2O. In so doing, ADP i reconverted to ATP (and othe phosphate-acceptors that may be present are similarly rephosphorylated). The stimulus to extra release of energy from carbohydrate stores thus disappears and he cell returns o its basal state of respiration and energy release.

Glycogen

Glucose-1 PO_4 (1 mole)

Pyruvate (2 moles)

CO_2 & H_2O

ATP (39 moles)

ADP (39 moles)

PO_4 (39 moles)

ATP (39 moles) dephosphorylated, with release of terminal PO_4 and of free energy for cell function

Energy for Cell Function

Excitation

1 mole of PO_4

8 moles of PO_4

30 moles of PO_4

9 moles of ADP

30 moles of ADP

30 moles of ATP

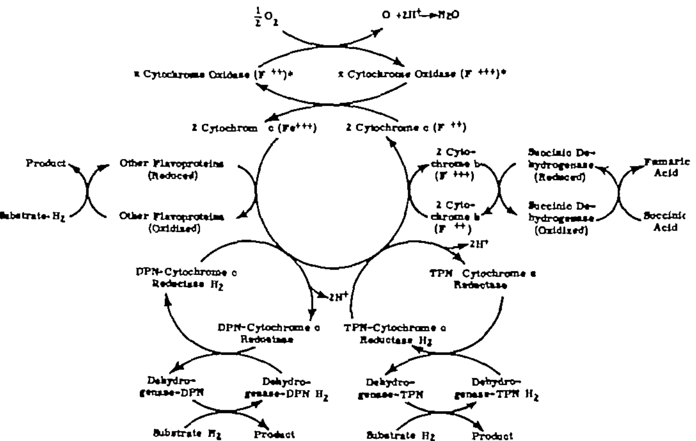
3 moles of ATP

6 moles of ATP

/1/ When the stimulus is withdrawn, respiration continues at the elevated rate only until the organ is restored to its original state. With no compounds remaining in the unphosphorylated state the respiration machinery stops with the various enzymes blocked in the acylated and/or phosphorylated states /2/ The quantity of ATP assumed, 39 moles, is adjusted to the catabolism of 1 mole of glucose-1-PO_4 or 1 mole of 6-carbon unit, component of glycogen. /3/ Approximately 13-16 kilocalories of free energy per mole of ATP converted to ADP or 500-600 kilocalories for the quantities represented in the diagram. Energy used for muscle contraction, and for synthesis /4/ Other high energy carriers than ATP (adenosine triphosphate) and other phosphate acceptors than ADP (adenosine diphosphate) may also function (e.g., creatine phosphate and creatine--also phosphates of guanosine cytidine and uridine) /5/ Rate of energy release from stored carbohydrate probably controlled by concentration of phosphate acceptors capable of forming high energy carriers (cf Fn 4) /6/ In inorganic phosphate pool. /7/ These 8 moles include 2 that combine with 2 moles of 3-glyceraldehyde-3-phosphate ("substrate phosphorylation") and are then transferred to ADP, and 6 that combine directly with ADP in association with the oxidation of 4 moles of hydrogen [illegible] electron transport phosphorylation"--see table 108, also Fn 13, table 305) /8/ One PO_4 combines with one 6-carbon unit in glycogen [illegible] /9/ Not shown in diagram. One mole of ATP is required at an early step in the reaction: glucose-1-PO_4→pyruvate, and 4 moles of ATP are formed at later steps. The net gain is 3 moles of ATP. The 3 moles of PO_4 have come from the 1 mole combined into glucose-1-phosphate (cf Fn 8) and 2 of the 8 moles covered by Fn 7. /10/ Pyruvate is converted to lactate by reaction with $DPNH_2$ if the latter has accumulated, as in conditions of relative oxygen deficiency /11/ Energy from carbohydrate metabolites is built into the ATP molecule /12/ Via Krebs Cycle

108 THE CYTOCHROME SYSTEM

The cytochromes (iron-containing compounds) in association with certain othe compounds constitute the "Cytochrome System The system operates as the final pathway by which an intermediate metabolite (sub rate) under the influence of its specifi dehydrogenase releases hydrogen to the first member in series of carriers for ultimate combination with oxygen to form water Each step in the proce s involves both oxidation and reduction: The cytochrome system oxidizes the hydrogen of the substrate by removing lectrons from it, thereby producing oxidized substrate and hydrogen ions and the system itself is reduced in the process and is finally oxidized by molecular oxygen For each gram of hydrogen thus passed and finally oxidized enough energy is produced to form 1 5 moles of ATP from ADP and PO_4



*Cytochrome a and cytochrome 3 have not been proved to be separate enzymes For the present therefore there is only one enzyme that acts between cytochrome and molecular oxygen. This component is termed cytochrome oxidase

109 PATHWAYS OF IRON METABOLISM MAMMALS

Iron in Ingested Food

Heme Iron

Fe^{+++}

Fe^{++}

Release of Iron by Intestinal[1] Bacterial Action

Reduction by Foodstuffs in Acid Medium of Stomach

Fecal Loss of Unabsorbed Iron

Fe^{++} of Intestinal[2] Contents

Ferritin Fe^{+++} of Intestinal Mucosa

Metabolically Active Iron Compounds of Tissues Myoglobin, Catalase Cytochromes

Plasma F^{+++} Combined with Fraction IV 1 (Globulin Iron Complex)

Ferritin Fe^{+++} of Liver and Spleen

Ferritin Fe^{+++} of Bone Marrow

Formation of Hemoglobin (Fe^{++}) in Bone Marrow

Circulating Hemoglobin (Fe^{++}) in Red Cells

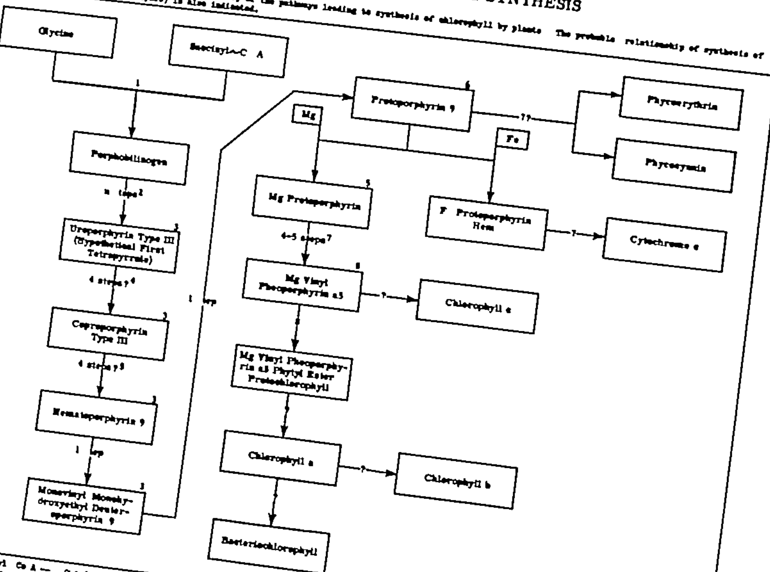
Degeneration of Red Cells

F^{+++}

/1/ Large intestine /2/ Small intestine

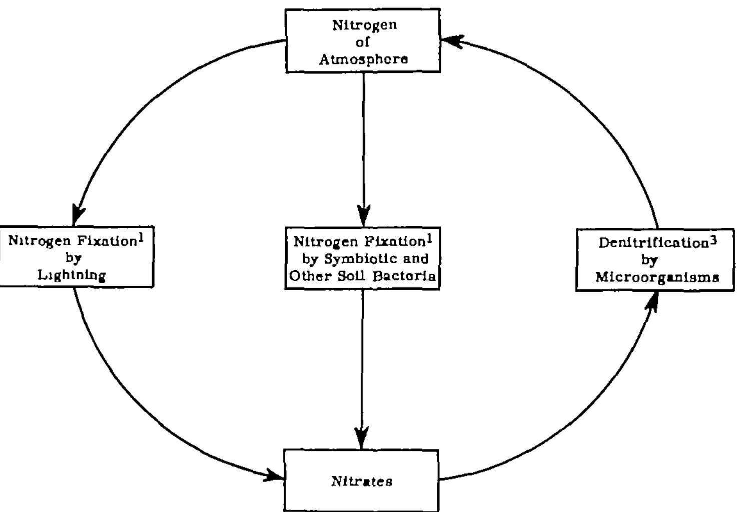
110 PATHWAYS OF CHLOROPHYLL SYNTHESIS

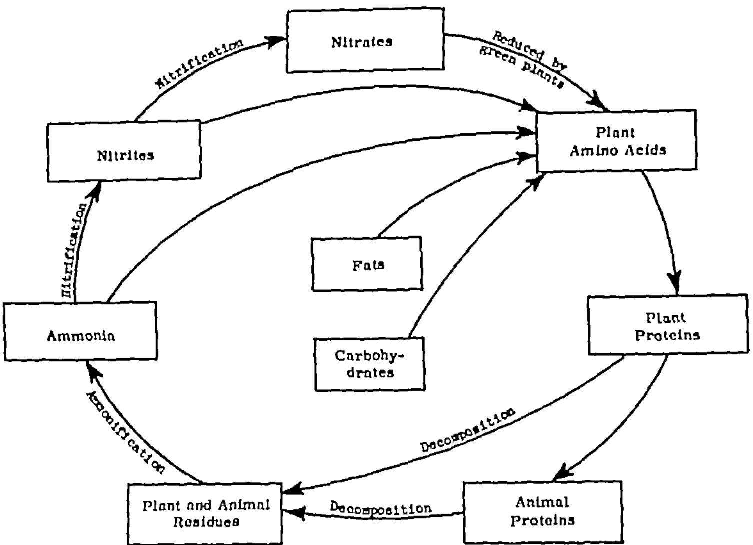
The diagram summarizes present knowledge and theory of the pathways leading to synthesis of chlorophyll by plants. The probable relationship of synthesis of cytochrome-c (and other heme enzymes) is also indicated.



/1/ Gl ine succinyl Co A — Gi ine β-keto adi ic acid. This compound is then synthesized in a δ-amino-levulinic acid, precursor for porphobilinogen. /2/ Four ... ted units for ... rin. Eight lysine molecules and ei ht molecules of succinyl~Co A ha e articipated. /3/ Fo ...

111 THE NITROGEN CYCLE IN NATURE





/1/ Atmospheric nitrogen is converted into nitrates /2/ Bacteria living in root cells of leguminous plants /3/ Nitrates are converted into gaseous nitrogen oxides or into free nitrogen

112 PARTITION OF EXCRETED NITROGEN: ANIMALS (Section I)

(See p 202ff for columns L-T of this table)

Values are grams of nitrogen in the combination specified in the column headings per 100 grams of total nitrogen excreted.

	Species	Allantoin-N Value	Allantoin-N Range	Amino Acid-N Value	Amino Acid-N Range	Ammonia-N Value	Ammonia-N Range	Creatine-N Value	Creatine-N Range	Creatinine-N Value	Creatinine-N Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	VERTEBRATA										
2	Mammalia										
3	Man (Homo sapiens)1 2					4.8	3.2-5.1	2 77	3.1-5.9	3.6	
5	Alpaca (Auchenia vicunna)1 3									4.6	
6	Bat (Xantharpyia (spp))1,2			0 96		4 5			8.5	8.5	
7	Camel bactrian (Camelus bactrianus)1					6		2.1			
8	Camel bactrian (C bactrianus)1 4 5			1 7							
9	Camel dromedary (C dromedarius)1 4				1.2-2.1	2 4	1 7 3.8				
10	Cat domestic (Felis catus)1				0.2 1 7	15 7	12 3-19.1	3.8?	11.1 13.1	10.1	
11	Cat domestic (F catus)1,2 6						5 9-8.1		17.6-18.17	14	
12	Cat domestic (F catus)1 2 7						4-4 9				0 57 1 9
13	Cat domestic (F catus)1 2 8						5 9-7 9		0.6-0.9		
14	Cat domestic (F catus)1 2 9						5 5-5 5		2.2-3.9		
15	Dog, domestic (Canis familiaris)1,2						5 7 11.1		0.45-1.07		
16	Hyena (Hyaena (spp))1,2	1 75	0 95		3 5		3.5-28		1.49-2.46	0.8	
17	Leopard (Panthera pardus)1,2	0 52	0.86		4.0			0.89	0.9-10	0.79	
18	Llama (Llama glama)1,2	21.4	1.4		3.2			0.44	0.88	0.88	
19	Seal harbor (Phoca vitulina)1 11			1.3-1 4	2.0	1.8-2.2	2.2		1.38		
20	Seal harbor (P vitulina)1 10,11					8-16			9.1-11.7	8.3	
21	Seal harbor (P vitulina)1 10,12					9	9-16.8	6.8	12.9-31		
22	Tiger (Panthera tigris)1,2	1 5	0.95		3 3	2 7 5			9.1 31		
23	Weasel (Mustela (spp))1 2	0 48	0.89		2.6		0.43		1.72	1.29	
24	Whale finner (Balaenoptera physalus)1,10						1.57		1.67	0.3	
25	Whale sei (B borealis)1,10				5 7	1 1 5	5.2-9.4		Trace		
									0.5-3.8		
									0.810.2-1.9		

	VERTEBRATA (cont d)										
	Aves										
33	Duck (Anas (spp))1,13					3.2					
34	Fowl, domestic (Gallus domesticus)1,2			6		1 5	1 5-17 5			8	
35	Fowl, domestic (G domesticus)1,2						14 9-19		7.4-9.1		
36	Fowl domestic (G domesticus)1 8						3-4				
37	Goose (Anser (spp))1,13					13 5					
38	Swan (Cygnus (spp))1,13					15.8					
	Reptilia										
39	Alligator (Alligator (spp))1						37 76				
40	Alligator, American (A (spp))1,14						66-81				
41	Lizard (Chalcides ocellatus)1,2	2 7									
42	Lizard (Scincus officinalis)1,2	1 6									
43	Lizard, European (Lacerta (spp))										
44	Lizard horned (Phrynosoma cornutum)1,4					0 6?				Trace	
45	Python (Python (spp))1,2			2 3		8 7					
46	Snake (Eryx thebaicus)1,2	0		1.1		5 7			0.25		
47	Snake (Tropidonotus (spp))					Trace					
48	Snake (Zamenis diadema)1,2	0		4 5		4 5					
49	Tortoise (Chelone mydas)1					16.1		2.6	0.9		
50	Tortoise (C mydas)1,15						79-51		5.5-11.5		
51	Tortoise (Emys orbicularis)1,13		0 5-0 9	19 7	15.8-21 9	14 4	10 6-18.8				
52	Tortoise (Kinixys erosa)1,2	0.4		13 7	12 7 14 7	6 1	5 7-6 5				
53	Tortoise (K. youngi)1,15		0 5-1.5	15.2	7 7-22	6	2 9-12 5				
54	Tortoise (Kinosternon subrubrum)1,15	1.1		10		Ca					
55	Tortoise (Pelusios derbianus)1,15	1		20 6		18.5					
56	Tortoise (Testudo alagona)1,4		1 1.2	15.1	10.6-15 5	6.2	5 9-6 5				
57	Tortoise (T graeca)										
58	Tortoise (T graeca)1,2		1.4-1 9	6 6	4 5-8 6	4.1	4.0-4.1				
59	Tortoise (T denticulata)1 2		6 7-8 6	15 6	9 4-22.9	6	3 9-8 7				
60	Tortoise, painted western (Chrysemys picta)1,15			11.5?	5.8-8.27	15.3	9.8-20 7		5.5		
61	Turtle ((Genus) (spp))1,15						14 5-17 7		3 5-11.3		
	Amphibia										
62	Frog (Rana catesbiana)1										
63	Frog (R virescens)1 14,16						3-38				
64	Frog (R (spp))1,14,17					5.1	1.2-7 4				
65	Frog (R (spp))1,14,18					20 9 12.2					
	Pisces										
66	Bowfin (Amia calva)1,11,14			8 7		32					
67	Carp (Cyprinus (spp))1,19			2 6			73-77		20.5		

/1/ Urine analyzed. /2/ Terrestrial habitat /3/ Mountain habitat /4/ Dry terrestrial /5/ Pregnant specimen /6/ Purine-rich diet /7/ Purine-free diet /8/ Protein-rich diet /9/ Low protein diet /10/ Marine form. /11/ Fasting /12/ Feeding /13/ Semi-aquatic /14/ Fresh-water /15/ Aquatic /16/ Hibernating specimen /17/ Kept at 11°C /18/ Kept at 22°C /19/ Analysis made from a small portion of the surrounding medium

112 PARTITION OF EXCRETED NITROGEN: ANIMALS (Section I)

(See p 202ff for columns L-T of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Allantoin-N Value g/100 g	Allantoin-N Range g/100 g	Amino Acid-N Value g/100 g	Amino Acid-N Range g/100 g	Ammonia N Value g/100 g	Ammonia N Range g/100 g	Creatine-N Value g/100 g	Creatine-N Range g/100 g	Creatinine-N Value g/100 g	Creatinine-N Range g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	VERTEBRATA (concluded)										
	Pisces (concluded)										
68	Carp (Cyprinus carpio)			2 6			60-78				
69	Carp (C. carpio)[1,11,14]						3.3-21 6	18.2-28			
70	Catfish (Ictalurus furcatus)[1,14]			20		27		7.9			
71	Cod (Gadus callarias)[10,11,20]				14 8-21 4			33-56			
72	Dogfish (Mustelus (spp.))					7 3					
73	Eel (Anguilla chrysypa)[1,11,14]						11 7-29.4	21.8-32			
74	Flounder (Pseudopleuronectes americanus)[1,10]			8 9	8.2-9 7	2.2	1.8-2.6			20.5	
75								15.0-25			
76	Gar, longnosed (Lepisosteus osseus)[1,14]			4 1		34		4.1			
77	Goldfish (Carassius auratus)[21]					73					
78	Goldfish (C. auratus)[1,11,14]						6.2 15 7	11.9-19.2			
79	Goosefish; Anglerfish (Lophius piscatorius)[1,10]			8 4	5 3-15 4	0.6	0 3-1 3			2.6	
80								24.5-64			
81	Goosefish; Anglerfish (L. piscatorius)[10,22]										
82	Goosefish; Anglerfish (L. piscatorius)[10,20]				14 9-34		2 5 4	21 47			
83	Goosefish; Anglerfish (L. piscatorius)[1,10]			9		2					
84	Lungfish (Protopterus (spp.))[1,23]					41		0.24		6.28	
85	Lungfish (Protopterus aethiopicus)[1,14]					61		10.2			
86	Minnow (Hyborhynchus (spp.))					75					
87	Puffer (Sphaeroides maculatus)[10,11,20]			20.6			5.1-6.2	12.1-59			
88	Red grouper (Epinephelus morio)[1,11,14]			6.4				17.1			
89	Sculpin (Myoxocephalus octodecimspinosus)[1,10]			4 2	4.4 4	1 6	1 5-2			15	
90								22.5-35			
91	Seahorse (Hippocampus (spp.))[10,19]			13.8		63					
92	Sheepshead (Archosargus probatocephalus)[1,11,14]				15-19 9		8 4-9.6	15.7 15.5			
93	Sole (Solea (spp.))[10,19]					53					
94	Torpedo; Numbfish (Torpedo (spp.))[10,19]			0 8		5.8					
95	Torpedo; Numbfish (T. (spp.))[1,19]			1.7		1 7					
	ARTHROPODA										
	Insecta										
96	Blowfly (larva) (Calliphora (spp.))[2,24]					Trace					
97	Blowfly (larva) (Lucilia (spp.))[2,24]					Trace[25]		Trace			

	ARTHROPODA (cont'd)										
	Insects (concluded)										
98	Cone-nose bug (Rhodnius prolixus)1,2			0		0		Trace		0	
99	Grasshopper (larva) (Melanoplus (spp.))24			17 7		3 3					
100	Grasshopper (M. bivittatus)24				6.2-8		1.6-1 7				
101	Moth (Antheraea pernyi)2,24	0				22.4					
102	Moth (A. pernyi)2,26	0				6 2					
103	Moth (A. pernyi)2 27	0				2.6					
104	Moth (larva) (A. pernyi)					4.4					
105	Moth (A. pernyi)28					3 1					
106	Moth (A. pernyi)29					4 7					
107	Moth (A. pernyi)2,27					4 1					
108	Moth (A. pernyi)31			9 5		1.8					
109	Moth (A. pernyi)2 31			3 1		9.6					
110	Moth (Saturnia pyri)2 31			2 7		0 3					
111	Moth (Sphinx ligustri)31			9 5		3.8					
112	Moth (S. ligustri)2 31			2 9		1.2					
113	Moth case-making cloth (Tinea pellionella)			10		10.2					
114	Moth clothes (Tiniella crinella)					20 7					
115	Moth webbing clothes (Tineola bisselliella)2 24					12 7					
116	Silkworm (Bombyx mori)										
	Crustacea										
117	Amphipod (Gammarus locusta)32 33				5-8		74-91				
118	Amphipod (G. pulex)14 32				0-10		58-82				
119	Amphipod (G. zaddachi)32 33				0-6		73-88				
120	Amphipod (Marinogammarus marinus)32 33				4-8		68-87				
121	Amphipod (M. pirloti)32,33				0-9		79-96				
122	Amphipod (Orchestia (spp.))10 32,34				6-26		51-91				
123	Crab (Cancer pagurus)1 10			20		45					
124	Crab (Eriocheir sinensis)10 19					72?	27-97				
125	Crab shore (Carcinus maenas)10,19			8 7	3 7-8 7	68	67-69				
126	Crab, shore (C. maenas)			7 7		71.4					
127	Crab, spider (Maja squinado)1,10			28	16 4-28	12 4	4-12 4				
128	Crayfish (Astacus fluviatilis)14,19			10.1	3 9-12 5	60	53-65				
129	Crayfish (A. fluviatilis)11,14 19			3 9		62					
130	Crayfish (A. fluviatilis)12,14,19			11 8		65					
131	Isopod (Armadillidium vulgare)14,32				0-11		51 59				
132	Isopod (Asellus aquaticus)14 32				3-21		55-71				
133	Isopod (Ligia oceanica)10 32,34				0-13		38-99				
134	Isopod (Oniscus asellus)2,32				0-12		44 50				
135	Isopod (Porcellio laevis)2 32				0-8		56-58				

/1/ Urine analyzed. /2/ Terrestrial habitat. /10/ Marine form. /11/ Fasting. /14/ Fresh-water /19/ Analysis made from a small portion of the surrounding medium /20/ Urine for analysis within 24 hours post-mortem. /21/ Gills and urine analyzed. /22/ Ammonia removed by distillation from urine analyzed. /23/ Active specimen. /24/ Feces analyzed. /25/ This constituent found if meat is fed. /26/ Analysis from extract of malpighian tubules /27/ Exuvial fluid analyzed. /28/ Over winter pupa. /29/ Early pupa. /30/ 4 week pupa. /31/ Meconium analyzed /32/ Medium and solid excreta analyzed. /33/ Marine-littoral form. /34/ Semi terrestrial form.

112 PARTITION OF EXCRETED NITROGEN ANIMALS (Section I, Concluded)

(See p 202ff for columns L-T of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted

	Species	Allantoin-N Value	Allantoin-N Range	Amino Acid-N Value	Amino Acid-N Range	Ammonia N Value	Ammonia N Range	Creatine-N Value	Creatine-N Range	Creatinine-N Value	Creatinine-N Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	MOLLUSCA										
	Cephalopoda										
136	Cuttlefish (Sepia officinalis)1,10			7.8	7.2-8.4	67	64-70				
137	Octopus (Octopus vulgaris)1,10			18 9			35-48?				
138	Octopus (O. vulgaris)10,19			20		50					
	Gastropoda										
139	Periwinkle (Littorina littorea)10,19,55			7		12 6					
140	Periwinkle (L. littorea)10,19 46			10		1.9					
141	Sea hare (Aplysia (spp.))10,19			23.0		34	30-37				
142	Sea-hare (A limacina)10 19,37			15 0		37					
143	Sea-hare (A limacina)10,37,38			31		14					
144	Sea-hare (A limacina)10,19,39					30					
145	Sea-hare (A limacina)10,38,39			52		8.2					
146	Slug (Arion empiricorum)12 40			18 0	11.5-18 0	9.8	7.1-9.8				
147	Slug (Limax agrestis)12,40				0 5-2.9		4.2-5.0				
148	Snail, edible (Helix pomatia)12,11,40			7.0		22.2					
149	Snail, edible (H. pomatia)12,12,40			5.2		13 7					
150	Snail, edible (H. pomatia)12 11,40				5 5-10		12 5-37				
151	Snail, edible (H. pomatia)12,12 40				5.2-6.4		7.1-66				
152	Snail, fresh-water (Paludina vivipara)14,19,35,40			27		4 4					
153	Snail, fresh-water (P vivipara)14,19,36,41				29	13 1					
154	Snail, pond (Limnaea stagnalis)					13 8					
155	Snail pond (L. stagnalis)14,19,36			26		9.0					
	Pelecypoda										
156	Clam (Mya arenaria)10,19			18		21 5					
157	Clam (M. arenaria)10,38			30		4.8					
158	Clam, fresh-water (Anodonta cygnea)41					60					
159	Clam, fresh-water (A cygnea)14,42					6.86	4 7-8				
160	Clam, fresh-water (A cygnea)14,43					40	16-61				
161	Mussel (Mytilus edulis)10 19			24.4	17.1 56	7 4	Trace-11.4				
162	Mussel, fresh-water (Unio pictorum)14,19,35					24.8					
163	Mussel, fresh-water (U pictorum)14,19,36			29		44					
164	Oyster (Gryphaea angulata)10,38			15.2		7.2					

	ANNELIDA										
165	Earthworm (Lumbricola agricola)[2,11,40]			20		46					
166	Earthworm (L. agricola)[2,12,40]			12.2	16-20	20 4	47-48				
167	Earthworm (Lumbricus terrestris)[2,12 44]					47					
168	Earthworm (L. terrestris)[2,12,24]				12.2-15	<10	20 4-47				
169	Earthworm (L. terrestris)[2,11,44]						66-91				
170	Earthworm (L. terrestris)[2,11 41]									7.8	
171	Earthworm, Indian (Pheretima posthuma)[1,2]			0.6		45					
172	Earthworm, Indian (P posthuma)[2,45]					64					
173	Earthworm, Indian (P posthuma)[2,40]					73					
174	Leech (Hirudo medicinalis)[11,14,19]			4 5		78					
175	Leech (H. medicinalis)[12,14 19]			1.9		74 5					
176	Leech (H. medicinalis)[14,19,42]					76	70-81				
177	Leech (H. medicinalis)[14,19,43]					45	34-60				
178	Leech (H. officinalis)[11,14,40]			3 5	3 5-5 5	79					
179	Leech (H. officinalis)[12,14 40]			3.3	0.6-3 3	71					
180	Sea-mouse (Aphrodite aculeata)[1]					80					
181	Sea-mouse (A. aculeata)[10,45]			55		13.3					
	Sipunculoidea										
182	Worm, marine (Sipunculus nudus)[10,19]			16.6		50					
	ECHINODERMATA										
183	Sea-cucumber (Holothuria tubulosa)[10,19]			18	18-18 7	59	39-41				
184	Sea-urchin (Paracentrotus lividus)[10,19]			28	25-29	28	26-30				
185	Starfish (Asterias rubens)[10,19]			24	17.3-28	59	25 7-48				
	COELENTERATA										
186	Sea-anemone (Actiniaria (spp))[19]					53					
	PROTOZOA										
187	Ciliate (Colpidium campylum)[14,19]					Present					
188	Ciliate (Didinium (spp))[14,19]					Present					
189	Ciliate (Glaucoma (spp))[14,19]			Present[46]		Present					
190	Ciliate (Paramecium (spp))[19]					91[47]					
191	Ciliate (P (spp))[14,19]					91					
192	Ciliate (P (spp))[11,14,19]					77[49]					
193	Ciliate (P (spp))[14,19,48]					76[51]					
194	Ciliate (P (spp))[14,19,50]					Present					
195	Ciliate (P caudatum)[14,19]										
196	Ciliate (Spirostomum ambiguum)[19]					Present[52]					
197	Ciliate (S ambiguum)[14,19]										
198	Flagellate (Bodo (spp))[14,19]					Present					

/1/ Urine analyzed. /2/ Terrestrial habitat /10/ Marine form. /11/ Fasting. /12/ Feeding /14/ Fresh-water /19/ Analysis made from a small portion of the surrounding medium. /24/ Feces analyzed. /35/ Summer /36/ Winter /37/ Small specimens /38/ Mantle cavity fluid. /39/ Large specimens /40/ Washings analyzed. /41/ Total excreta analyzed. /42/ Distilled water medium analyzed /43/ Acid medium analyzed. /44/ Analyzed from washings collected over 8 day period. /45/ Coelomic fluid analyzed. /46/ Amides /47/ With no substrate With glycine substrate 55% of N P N with starch substrate, 0. /48/ Fed glycine /49/ Non-amino nitrogen /50/ Fed fibrin /51/ Total nitrogen of medium. /52/ Zero at low O_2 (hypoxia)

112 PARTITION OF EXCRETED NITROGEN: ANIMALS (Section II)

(See p 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted

Species	Purine-N (Minus Uric Acid N)		Urea N		Uric Acid N		Other Specified N	Unidentified N	
	Value g/100 g	Range g/100 g	Value g/100 g	Range g/100 g	Value g/100 g	Range g/100 g	g/100 g	Value g/100 g	Range g/100 g
(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
VERTEBRATA									
Mammalia									
Man (Homo sapiens)1,2			87	83-90	1 4	0 5-1 5		4	2-6 4
Alpaca (Auchenia vicunna)1 3			60		0 3			28	
Bat (Xanthorpyia (spp))1,2			65		0.87			20 3	
Camel bactrian (Camelus bactrianus)1			68		1 3			14.8	
Camel, bactrian (Camelus bactrianus)1,4				65-69		0 8-1.8			14-16.1
Camel dromedary (Camelus dromedarius)1 4			44	35-96	0 3			16.2	13-20
Cat domestic (Felis catus)1				72-84		0 02-0.22			
Cat domestic (F catus)1 2 6				68-90	0.1				
Cat domestic (F catus)1,2,7				80-86	0.01				
Cat domestic (F catus)1 2 8				78-89		0 1-0 35			
Cat domestic (F catus)1 2 9				58-80		0-0 09			
Dog domestic (Canis familiaris)1,2		91		46-92			5	1 4-22	
Hyena (Hyaena (spp))1 2	0.23	89		0 06			2.8		
Leopard (Panthera pardus)1,2	0.29	87		0 06					
Llama (Llama glama)1,2		64	61-68	0.8					
Seal harbor (Phoca vitulina)1,11			65-80		6-11				
Seal, harbor (P vitulina)1 10,11			52 73						
Seal, harbor (P vitulina)1 10 12			61 90						
Tiger (Panthera tigris)1,2	0 18	89		0 06			3.4		
Weasel (Mustela (spp))1,2	0 58	91		0.16			2.6		
Whale finner (Balaenoptera physalus)1 10			90-95?	3	1.6-4 4			2 7 3 1	

VERTEBRATA (cont'd) Mammalia (concluded)			88	83-93	1.8	0.6-4.25		3 9	2 3-6.1
Whale, sei (Balaenoptera borealis)1,10 Aves Duck (Anas (spp))1,13 Fowl, domestic (Gallus domesticus)1,2 Fowl, domestic (G domesticus)1,2 Fowl domestic (G domesticus)1,13 Goose (Anser (spp))1,13 Swan (Cygnus (spp))1,13	8		4 2 0 9 10 2 6	0 9-10 4 9.2 11 5	72 70 87 80 69	63-87 59-70		20 7 28 0 6 5 13 9	0 3-2 9
Reptilia Alligator (Alligator (spp))1 Alligator, American (Alligator (spp))1,13 Lizard (Chalcides ocellatus)1,2 Lizard (Scincus officinalis)1,2 Lizard, European (Lacerta (spp)) Lizard, horned (Phrynosoma cornutum)1,4 Python (Python (spp))1,2 Snake (Eryx thebaicus)1,2 Snake (Tropidonotus (spp))1,2 Snake (Zamenis diadema)1 Tortoise (Chelone mydas)1 Tortoise (C mydas)1,15 Tortoise (Emys orbicularis)1,13 Tortoise (Kinixys erosa)1,2 Tortoise (K. youngi)1,2 Tortoise (Kinosternon subrubrum)1,15 Tortoise (Pelusios derbianus)1,15 Tortoise (Testudo elegans)1,4 Tortoise (Testudo graeca) Tortoise (T graeca)1,2 Tortoise (T denticulata)1,2 Tortoise, painted western (Chrysemys picta)1,15 Turtle ((Genus) (spp))1,15 Amphibia Frog (Rana catesbiana)1	0 3 2 0		0 0 0 Trace 2 0 38 47 61 44 22 9 24 4 8 5 90 22 3 29 39	4-24 1 3-17 0-12 26-69 50-72 50-75 7.8-9.1 15 3-29 3 27 31 24.1-48 31-45 62-88	93 94 91 98? 89 63 80 67 16 5 2 5 4.2 5 5 0 7 4 5 56 Trace 52 6 7 18 8	11 39 7 19.8 1 4-6 5 1 4-4 3 5-5 3 4-8 7 54-58 49-55 4 9-7 7 7 4-28 14-19 1 Trace-0 4	0 95[53] 2 7[53] 8-23[53] 0 5-1.2[54] 0 4[54] 0 3-3.8[54] 1[54] 3 8[54] 0 9-5.1[54] 8 7 10.1[54] 1 7 5[54]	Trace 29.1 9 37 14.8 15.2 26 40 27 12 4 32 18.6 7.25	0.2-23 2 4-22 16 6-41

/1/ Urine analyzed. /2/ Terrestrial habitat /3/ Mountain habitat /4/ Dry terrestrial /5/ Pregnant specimen. /6/ Purine-rich diet
/7/ Purine-free diet /8/ Protein-rich diet /9/ Low protein diet /10/ Marine form /11/ Fasting /12/ Feeding /13/ Semi-aquatic
/14/ Fresh-water /15/ Aquatic /53/ Hippuric acid nitrogen. /54/ Guanine and xanthine nitrogen.

112 PARTITION OF EXCRETED NITROGEN: ANIMALS (Section II)

(See p 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted

	Species	Purine-N (Minus Uric Acid N)		Urea-N		Uric Acid N		Other Specified N	Unidentified N	
		Value	Range	Value	Range	Value	Range		Value	Range
		g/100 g	g/100g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100g
	(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
	VERTEBRATA (concluded)									
	Amphibia (concluded)									
63	Frog (Rana virescens)1 14 16			87	82-91	0 3	0.2-0 4			1 9-13 7
64	Frog (R (spp))1 14,17			68					10 9	
65	Frog (R (spp))1 14 18			73					10.2	
	Pisces									
66	Bowfin (Amia calva)1 11,14			13 6		22 6				
67	Carp (Cyprinus (spp))14,19				12 5-14 5					5 5-12 5
68	Carp (C carpio)				6-15	0.2			22	
69	Carp (C carpio)1,11,14			7		0 6				32-79
70	Catfish (Ictalurus furcatus)1 14			24 6					16 9	
71	Cod (Gadus callarias)10,11,20				6 5-11.2		1 7-2 4		15.2 19	
72	Dogfish (Mustelus (spp))			81		0.2				
73	Eel (Anguilla crysypa)1,11,14				10 7-23 4		1.3-5 4			17 1 56
74	Flounder (Pseudopleuronectes americanus)1 10			17 3	13 5-21.2	1.2	1.2 1.3	0 4-1[75]	50	48 3-51.1
75										
76	Gar longnosed (Lepidosteus osseus)1 14			5 0					53	
77	Goldfish (Carassius auratus)21			9 9					16 8	
78	Goldfish (C auratus)1,11,14			Trace		1.1				71 73
79	Goosefish; Anglerfish (Lophius piscatorius)1,10			0 9	0.1 2 7	0.2	0.2-0 4	37[55]	5.27	28-63†
80										
81	Goosefish; Anglerfish (L ~icentorius)10,22							60[55]	20	
82	Goosefish; Anglerfish (L piscatorius)10,20				1 5-3 6		0 7 1.8			20-51
83	Goosefish; Anglerfish (L. piscatorius)1,10			28					65	
84	Lungfish (Protopterus (spp))1,23			18 5		0 8				
85	Lungfish (P aethiopicus)1,14			28		1.2				
86	Minnow (Hyborhynchus (spp))			12 3						
87	Puffer (Spheroides maculatus)10,11,20				1 8-19.1		0 8-1.2			9.1-85
88	Red grouper (Epinephelus morio)1,11,14			31					46	
89	Sculpin (Myoxocephalus octodecimspinosus)1,10			14 6	14.1 15.3	0 7		23[55]	55	54-56
90										
91	Seahorse (Hippocampus (spp))10 19			0 9					14.2	

No.	Species									
	VERTEBRATA (concluded)									
	Pisces (concluded)									
92	Sheepshead (Archosargus probatocephalus)1 11,14				~2 9-83		6 4-8 4			25-76
93	Sole (Solea (spp))10,19			16 6					40 4	
94	Torpedo; Numbfish (Torpedo (spp))10,19			91					4 0	
95	Torpedo; Numbfish (Torpedo (spp))1,19			65					11 5	
	ARTHROPODA									
	Insecta									
96	Blowfly (larva) (Calliphora (spp))2,24			Trace		Trace,2?				
97	Blowfly (larva) (Lucilia (spp))2,24			Trace22		Trace				
98	Cone-nose bug (Rhodnius prolixus)1,2			Trace		90-99				
99	Grasshopper (Melanopus (spp))24			8 7		70				8-10
100	Grasshopper (M. bivittatus)2,24				6.6-8 4		82-86			
101	Moth (Antheraea pernyi)2,24			0		73			5	
102	Moth (A pernyi)2,26			9 4		77			5	
103	Moth (A pernyi)2,27			0		76			21 5	
104	Moth (larva) (A pernyi)			6 7		89				
105	Moth (A pernyi)28			7 7		85				
106	Moth (A. pernyi)29			7 4		86				
107	Moth (A. pernyi)30			8		85				
108	Moth (A. pernyi)31			Trace		80				
109	Moth (A. pernyi)2 31			Trace		76				
110	Moth (Saturnia pyri)2 31			Trace		25				
111	Moth (Sphinx ligustri)31			Trace		81				
112	Moth (S ligustri)2 31			Trace		25				
113	Moth, case-making clothes (Tinea pellionella)			17.6		47 5				
114	Moth, clothes (Tiniella crinella)			1.8		77 5				
115	Moth, webbing clothes (Tineola bisselliella)2,24			1 5		47				
116	Silkworm (Bombyx mori)			0		86			59	
	Crustacea									
117	Amphipod (Gammarus locusta)32,33		2-4		Trace-3					5-22
118	Amphipod (G pulex)14,32		7-20		5-15					2 16
119	Amphipod (G zaddachi)32,33		1-4		0-4					2 17
120	Amphipod (Marinogammarus marinus)32,33		4-18							2-18

/1/ Urine analyzed. /2/ Terrestrial habitat /10/ Marine form. /11/ Fasting. /14/ Fresh-water /16/ Hibernating specimen. /17/ Kept at 11°C /18/ Kept at 22°C /19/ Analysis made from a small portion of the surrounding medium. /20/ Urine for analysis obtained within 24 hours post-mortem. /21/ Gills and urine analyzed. /22/ Ammonia removed by distillation from urine analyzed. /23/ Active specimen. /24/ Feces analyzed. /25/ This constituent found if meat is fed /26/ Analysis from extract of malphigian tubules /27/ Exuvial fluid analyzed. /28/ Over winter pupa /29/ Early pupa. /30/ 4 week pupa /31/ Meconium analyzed /32/ Medium and solid excreta analyzed. /33/ Marine-littoral form. /35/ Trimethylamine oxide nitrogen. /36/ Allantoic acid excreted, uric acid stored

112 PARTITION OF EXCRETED NITROGEN: ANIMALS (Section II)

(See p 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Purine-N (Minus Uric Acid N) Value	Purine-N Range	Urea-N Value	Urea-N Range	Uric Acid-N Value	Uric Acid-N Range	Other Specified N	Unidentified N Value	Unidentified N Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
	ARTHROPODA (concluded)									
	Crustacea (concluded)									
121	Amphipod (Marinogammarus pirloti)[32,33]		1 3							4-18
122	Amphipod (Orchestia (spp.))[10,32,34]		6-11		0-3					7 17
123	Crab (Cancer pagurus)[1,10]	10		12 9		2 8			11 5	4-11 9
124	Crab (Eriocheir sinensis)[10,19]			5		Trace[37]				
125	Crab shore (Carcinus maenas)[10,19]	3.2	2 ?-3.2	3	3-4.2	0 7	0.2 1.2			17 3-20.1
126	Crab, shore (C maenas)	3 9		2.2		0 6				
127	Crab, spider (Maja squinado)[1,10]	6 6	0-7 4	2.1	2 1-8 5	1 3	1 3-4 7			51 71
128	Crayfish (Astacus fluviatilis)[14,19]	4 4	3.2-6 4	11.2	10.2-11.8	0 8	0 3-1.2		14 7	
129	Crayfish (A fluviatilis)[11,14,19]	6 4		11 7		1.2			13.1	
130	Crayfish (A fluviatilis)[11,14,19]	3 7		11.8		0 8			7 4	
131	Isopod (Armadillidium vulgare)[14,32]				0-2		4-13			23-27
132	Isopod (Asellus aquaticus)[14,32]		0-13				1 9			14-37
133	Isopod (Ligia oceanica)[10,32,34]		0-6							1 24
134	Isopod (Oniscus asellus)[2,32]		14-38				4-5			8-25
135	Isopod (Porcellio laevis)[2,32]		10-20				2-6			18-28
	MOLLUSCA									
	Cephalopoda									
136	Cuttlefish (Sepia officinalis)[1,10]	4 9	3.2-4 9	1 7	1 4-2 1	2.1	2.1-2.2			18.6-20.2
137	Octopus (Octopus vulgaris)[1,10]	29		13 07		1.47			29	
138	Octopus (O vulgaris)[10,19]			13		2			14	
	Gastropoda									
139	Periwinkle (Littorina littorea)[10,19,35]	29		140		0.8			11	
140	Periwinkle (L littorea)[10,19,36]	16		61		1.1			10 4	
141	Sea-hare (Aplysia (spp.))[10,19]		15-16 7	8 7	7 4-10	4 6	Trace-9.8			24 1-45
142	Sea hare (A limacina)[10,19,37]	18 5		7 4		9.2			14 9	
143	Sea hare (A limacina)[10,37,38]	3 9		3 9		2.3			45	
144	Sea hare (A limacina)[10,37,38]	13		10					45	
145	Sea-hare (A limacina)[10,38,39]	4.1		2.5		3.2			50 4	
146	Slug (Arion empiricorum)[2,40]	16.6	3-20.2	6 8		3 3	1.4-10 3			32-80

	MOLLUSCA (concluded)									
	Gastropoda (concluded)									
147	Slug (Limax agrestis)2,40		5.1 16 6	16 8	61-80	7??	3-6 9		35	6 9-7.2
148	Snail, edible (Helix pomatia)2,11,40	19		22		10 7??			43	
149	Snail, edible (H. pomatia)2,12,40	16 5	10-29 1		8-25.8		2 4-10			
150	Snail, edible (H pomatia)2,11,40		5.1 21 4		10-35		4-20			
151	Snail, edible (H pomatia)2,12,40								24	5-24
152	Snail fresh-water (Paludina vivipara)14,19,35,40	30		8.1		6.6			2.8	
153	Snail, fresh-water (P vivipara)14,19,36	31		13		10.8			39	
154	Snail, pond (Limnaea stagnalis)14,19,35			42 5		5			32	
155	Snail, pond (L stagnalis)14,19,36	27				4				
	Pelecypoda									
156	Clam (Mya arenaria)10,19	5		4 5		Trace			51	
157	Clam (M. arenaria)10,38			5		1.2			41	
158	Clam, fresh water (Anodonta cygnea)41									
159	Clam, fresh-water (A cygnea)14,42									
160	Clam, fresh water (A cygnea)14 43									
161	Mussel (Mytilus edulis)10,19	9 7	Trace-16	Trace		0			58.5	37 79 4
162	Mussel, fresh-water (Unio pictorum)14,19,35								75	
163	Mussel, fresh-water (U pictorum)14,19,36	20							6.1	
164	Oyster (Gryphaea angulata)10,38			5.2		1 6			75	
	ANNELIDA									
165	Earthworm (Lumbricola agricola)2,11,40	6		12					16	
166	Earthworm (L agricola)2,12,40			38					29	15 4-25
167	Earthworm (Lumbricus terrestris)2,12 44		4 6-6		6-12	0				
168	Earthworm (L terrestris)2,12,24				82-86				>10	10 5-29
169	Earthworm (L terrestris)2,11,44	17 5			10-38	0				
170	Earthworm (L. terrestris)2,11 41			<10						
171	Earthworm, Indian (Pheretima posthuma)1,2			55		0				
172	Earthworm, Indian (P posthuma)2,45			38						
173	Earthworm, Indian (P posthuma)2,40			25						
174	Leech (Hirudo medicinalis)11,14,19	4 5		3 8		0			9.1	
175	Leech (H. medicinalis)12,14,19	2 9		7		Trace			15 7	
176	Leech (H. medicinalis)14,19,42									
177	Leech (H medicinalis)14,19 43									

/1/ Urine analyzed. /2/ Terrestrial habitat /10/ Marine form. /11/ Fasting /12/ Feeding. /14/ Fresh-water /19/ Analysis made from a small portion of the surrounding medium. /24/ Feces analyzed /32/ Medium and solid excreta analyzed /33/ Marine-littoral form. /34/ Semi terrestrial form. /35/ Summer /36/ Winter /37/ Small specimens /38/ Mantle cavity fluid /39/ Large specimens /40/ Washings analyzed /41/ Total excreta analyzed /42/ Distilled water medium analyzed. /43/ Acid medium analyzed /44/ Analyzed from washings collected over 8 day period /45/ Coelomic fluid analyzed. /57/ Collection method probably did not insure complete recovery of uric acid

112 PARTITION OF EXCRETION NITROGEN ANIMALS (Section II, Concluded)

(See p 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings per 100 grams of total nitrogen excreted

	Species	Purine-N (Minus Uric Acid-N)		Urea N		Uric Acid N		Other Specified N	Unidentified-N	
		Value	Range	Value	Range	Value	Range		Value	Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
	ANNELIDA (concluded)									
178	Leech (Hirudo officinalis)11,14,40	5.2	3 3-5.2	3 5	3 5-4.2	0			8 7	
179	Leech (H officinalis)12 14,40	5 8	2-5.8	10	4-10	0			11.8	
180	Sea-mouse (Aphrodite aculeata)1			0.2		0 8				
181	Sea-mouse (A aculeata)10,45			11.1		1 1			59	
	Sipunculoidea									
182	Worm, marine (Sipunculus nudus)10,19	4.1		9 7		0			19 4	
	ECHINODERMATA									
183	Sea-cucumber (Holothuria tubulosa)10,19	12	12-12 5	6	6-6.25	0			25	18 7-27
184	Sea-urchin (Paracentrotus lividus)10,19	11		7 5	5-10	1				20.2-24.3
185	Starfish (Asterias rubens)10,19		3 6-10	11 7	8 0-15 7	Trace				16-26
	COELENTERATA									
186	Sea-anemone (Actiniaria (spp))19			42						
	PROTOZOA									
187	Ciliate (Colpidium campylum)14 19			Present		0				
188	Ciliate (Didinium (spp))14,19			0						
189	Ciliate (Glaucoma (spp))14,19			0		0				
190	Ciliate (Paramecium (spp))19			0						
191	Ciliate (P (spp))14,19			Present58						
192	Ciliate (P (spp))11,14,19									
193	Ciliate (P (spp))14,19,48								9	
194	Ciliate (P (spp))14,19,50									
195	Ciliate (P caudatum)14,19									
196	Ciliate (Spirostomum ambiguum)19			Present						
197	Ciliate (S ambiguum)19			Trace58						
198	Flagellate (Bodo (spp))14,19			0						

/1/ Urine analyzed. /10/ Marine form. /11/ Fasting /12/ Feeding. /14/ Fresh-water /19/ Analysis made from a small portion of the surrounding medium. /40/ Washings analyzed. /45/ Coelomic fluid analyzed. /48/ Fed glycine /50/ Fed fibrin. /58/ Urease used probably contained small quantities of ammonia, thereby rendering this value doubtful.

113 EXCRETION OF NITROGEN COMPOUNDS MAN

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions up to as high as 12 liters per day in extremely hot climates it has not been practicable to present data on excretion via sweat in terms of per kg body weight per day"

	Constituent	Excreted in Urine mg/kg body wt/da Value	Excreted in Urine mg/kg body wt/da Range[1]	Excreted in Feces mg/kg body wt/da Value	Excreted in Feces mg/kg body wt/da Range[1]	Excreted in Sweat mg/100 ml Value	Excreted in Sweat mg/100 ml Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Water total	17 000	7 800-27 500		910-1 820		
2	Solids total	860	780-1 000	394	140-560		
3	Nitrogen total[2 3]	347	85-500	24	11.4-36 0	31 0	27-64
4	Protein nitrogen		0 0046-0 018				
5	Non-protein nitrogen[3]	347	85-500			31 0	27-64
6	Amino acid nitrogen	2 5	2.2-4 4			4.4	1.57-4 76
7	Creatinine	15	12 25			4 25	0-6 68
8	Hippuric acid	8	1 12				
9	Urea	300	215-500			72	25-186
10	Uric acid	9	5-12			1.4	0 7 2 5
11	Ammonia[4]	9 2	4-18 2		0 56-1.2		2 5-35
	Amino Acids						
12	Alanine free						
13	Combined						
14	Total	0 55					
15	Arginine free	0 31	0 15-0 5				
16	Combined	0 1	0-0 2				
17	Total	0 4	0 34-0 5	3 8	2 9-5 0	13 5	5 8-21.4
18	Aspartic acid free	0 02	0 014-0 26				
19	Combined	2.3	1.2 3 7				
20	Total	2.32	0 37 3 7				
21	Citrulline free[5]	0 58	0 26-0 7				
22	Combined						
23	Total		0 345-0 79				
24	Cystine free	1.3	0 65-2 0				
25	Combined						
26	Total		1.5-2 4				
27	Glutamic acid free	0 52	0-1 07				
28	Combined	4 5	1 0-10 0				
29	Total	5 27	1 58-11 55				
30	Glycine free	10 1	9 0-12 0				
31	Combined						
32	Total		2 3-18 0				
33	Histidine free	2.7	0 94-4 8				
34	Combined	0 6	0 07 1 8				
35	Total	3	0 98-6 59	1.7	1.4-2 1	8 0	6-10

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate σ of the 95% range (cf Introduction) /2/ Nitrogen in excreta is present as nitrogen compounds and not as free nitrogen. /3/ Total N and NPN values have been calculated from the values listed for the individual nitrogen components Items No 6-11. See also Footnote 1 /4/ See also table on electrolyte excretion. /5/ Determined by paper chromatography identity not completely proven.

113 EXCRETION OF NITROGEN COMPOUNDS MAN (Continued)

Because of the high degree of variability in rate of sweat formation ranging from zero under some conditions up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day"

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat	
		mg/kg body wt/day		mg/kg body wt/da		mg/100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
	Amino Acids (concluded)						
36	Hydroxyproline, free						
37	Combined						
38	Total	0 02					
39	Isoleucine free	0 085	0 03-0 3				
40	Combined	0 2	0 06-0 4				
41	Total	0 3	0.11-0 6	4 3	3 3-5 5	2.3	1.0-3 6
42	Leucine free	0 14	0 05-0 25				
43	Combined	0 2	0 05-0 4				
44	Total	0 32	0 2-0 52	5 6	4 3-6 9	2.7	1.2-4 2
45	Lysine free	0 5	0 25-1 13				
46	Combined	0 6	0 2-1 1				
47	Total		0 48-2	5 7	4 5-6 9	2.3	1 4-3 2
48	Methionine, free	0 11	0 05-0 18				
49	Combined	0 05					
50	Total	0 14	0 12-0 17				
51	Ornithine free[2]	0.15					
52	Combined						
53	Total						
54	Phenylalanine, free	0 23	0 1-0 43				
55	Combined	0 1	0 04-0 2				
56	Total	0 33	0 21-0 6			2.2	1.0-3 5
57	Proline, free	0 12	0 05-0 21				
58	Combined	0 5	0 3-0 8				
59	Total	0 61	0.33-0 9				
60	Serine free	0 4	0 21-0 52				
61	Combined	0 25	0-0 5				
62	Total	0 65	0 33-1.4				
63	Threonine, free	0 37	0 17-0 62				
64	Combined	0 4	0.3-0 8				
65	Total	0 77	0 36-1 2	4 0	3 3-5 2	5 4	1.7 9 1
66	Tryptophan free	0 37	0 12-0 7				
67	Combined	0 3	0 009-0 4				
68	Total	0.7	0 23-1 3			1 1	0 4-1 8
69	Tyrosine, free	0 3	0 17-0 55				
70	Combined	0 5	0 08-0 9				
71	Total	0 79	0 33-1 45			3 2	1 2-5 0
72	Valine free	0 065	0 04-0 125				
73	Combined	0 2	0 09-0 4				
74	Total	0 3	0 21-0 45	4 6	3 6-6 2	3	1.3-4 3

/1/ Ranges are averages of ranges of values reported in the literature cited They may be considered to be equivalent to estimate σ of the 95% range (cf Introduction) /2/ Identity not proven

113 EXCRETION OF NITROGEN COMPOUNDS MAN (Concluded)

Because of the high degree of variability in rate of sweat formation ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of per kg body weight per day"

Constituent	Excreted in Urine mg/kg body wt/da		Excreted in Feces mg/kg body wt/da		Excreted in Sweat mg/100 ml	
	Value	Range[1]	Value	Range[1]	Value	Range[1]
(A)	(B)	(C)	(D)	(E)	(F)	(G)
Miscellaneous Compounds						
75 Methionine sulfoxide		0-0 51				
76 Indican	0 14	0 06-0 45				
77 Adrenaline[6]	0.16μg	0 07-0 51μg				
78 Taurine		0 105-0 2				
79 Allantoin	0 27	0 18-0 56				
80 Noradrenaline[6]	0 41μg	0.17-0 9μg				
81 Purine bases	0 41	0 18-0 92		2 3		
82 Guanidoacetic acid		0 25-0 51				
83 Histamine		0 2 1 0				
84 Creatine[7]	2.9	1 1 3 86				
85 Hydroxytyramine[6]		1.4-2 8μg				
86 Imidazole derivatives		1.35-9 4		0-0 2		

/1/ Ranges are averages of ranges of values reported in the literature cited They may be considered to be equivalent to estimate σ' of the 95% range (cf Introduction) /6/ The catechol amines expressed in micrograms /7/ Not normally present in the urine of adult males

114 EXCRETION OF LIPIDS MAN

Constituent	Excreted in Urine mg/kg body wt/da		Excreted in Feces mg/kg body wt/da		Excreted in Sweat mg/100 ml		Excreted in Sebum[1] g/100 g
	Value	Range[2]	Value	Range[2]	Value	Range[2]	Value
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1 Fat total			56	30 0-100			
2 Fat neutral				10-45			
3 Fat unsaponifiable			55	22 38[5]			
4 Fatty acids total			30	4-64			
5 Fatty acids free			16	4-38			28
6 Fatty acids unsaturated							15[4]
7 Cholesterol total		0-0 007	83	10-205			5[4]
8 Cholesterol free							2 5[4]
9 Paraffin							7 5[4]
10 Phosphatides							0 9[6]
11 Soaps			535	40-66			
12 Squalene							5[4]
13 Triglycerides							55[4]
14 Waxes[7]							15[4]

/1/ The data on sebum are not available in mg per kg body weight per day and are therefore presented in grams per 100 grams /2/ Ranges are averages of ranges of values reported in the literature ited. They may be considered to be equivalent to estimate σ' of the 95% range (cf Introduction) /3/Age 6-12 yr /4/From forearms only /5/ Age 10 months /6/Individual samples from forehead /7/ Include esters of cholesterol

115 EXCRETION OF VITAMINS AND HORMONES MAN

Because of the high degree of variability in rate of sweat formation ranging from zero under some conditions up to as high as 12 liters per day in extremely hot climates it has not been practicable to present data on excretion via sweat in terms of per kg body weight per day"

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat	
		µg/kg body wt/da		µg/kg body wt/da		µg/100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
	Vitamins						
1	Vitamins A D F		0-trace				
2	Ascorbic acid	380	130-790	70	60-70		0-200[2]
3	Biotin	0 4	0 53-0 75	1 9	0 65-6 64	trace[3]	
4	Carotenes				20-600[4]		
5	Choline	90	80 1,0				2 7 15 3
6	Cobalamin[5]	0 0004	0,00025-0 00079				
7	Vitamin E[6]			308	226-391		
8	Folic acid group[7]	0 2	0 03-0 3	4 3	1 8-7 7	0 6	0 53-0 88
9	Inositol	170	170-220			21	15-36
10	Nicotinic acid		11 105	52	12 124		7 22
11	N-Methyl nicotinamide	130	73-400				
12	Pantothenic acid	44	20-100	31 4	3 85-63 4	3 8	2 2-4 4
13	Para aminobenzoic acid	2 11	2 3	3 3	1 01-8 2	0 24	0 08-1 7
14	Pyridoxine		0 007-0 0098	5 4	2 4-10 4	0 084	0 08-0 18
15	Pyridoxal	3 0	0 7 3 4			3 2	0 4-8 23
16	Pyridoxamine	1 6	0 3-2 1				
17	4 Pyridoxic acid	51	9-160				
18	Riboflavine	14 3	0 2 22 3	14 7	8 0-23		0-0 5
19	Thiamine	2 6	0 43-5 6	7 8	0 67 18	0 015	0-0 6
20	Trigonelline		30-300				
	Hormones						
21	Androgens		30-100				
22	Estrogens		0 1-0 5				
23	Formaldehydogenic steroids		3-140				
24	17-Ketosteroids	♂160,♀100					
25	Oxycorticosteroids		1 0-6 0				

/1/ Ranges are averages of ranges of values reported in the literature cited They may be considered to be equivalent to estimate d of the 95% range (cf Introduction) /2/ Ascorbic and dehydroascorbic acid /3/ Present but not quantitated. /4/ Carotene and xanthophyll; 8-100 µg/kg body wt/da for xanthophyll alone /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity /6/ A generic term for alpha beta delta and gamma tocopherols /7/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin) vitamin M vitamin B_c factor U L. casei factor Norite eluate factor

116 EXCRETION OF MISCELLANEOUS ORGANIC COMPOUNDS MAN

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day"

Constituent	Excreted in Urine per kg body wt/da		Excreted in Feces per kg body wt/da		Excreted in Sweat per 100 ml	
	Value	Range[1]	Value	Range[1]	Value	Range[1]
(A)	(B)	(C)	(D)	(E)	(F)	(G)
1 Acetone bodies, mg	0 285	0 03-0 7			3 08	0-16
2 Reducing substances, mg		7-20				2 8-40
3 Sugars, as glucose, mg	1 4					
4 Volatile acids, total, ml of 0 1 N			2 66	1 61-4 45		2 4-5 6
Organic Acids						
5 Citric acid, mg		3-17			0 2	
6 Formic acid, mg		0 4-2				
7 Indole acetic acid, mg		0 03-0 06				
8 Lactic acid, mg	40				225	45-452
9 Oxalic acid, mg	0 285	0 23-0 5				
10 Phenols, mg	4	0 19-6 6		0-3		2-8
Pigments						
11 Bilirubin, µg	70					
12 Coproporphyrin I, and III, µg		0 24-1 4				
13 Urobilin, µg		7 20				
14 Urobilinogen, µg		0 6 3	2	0 57-4		
15 Porphyrins, µg		0-0 4				

/1/ Ranges are averages of ranges of values reported in the literature cited They may be considered to be equivalent to estimate "d of the 95% range (cf Introduction)

117 EXCRETION OF ELECTROLYTES AND MINOR MINERALS MAN

Because of the high degree of variability in rate of sweat formation ranging from zero under some conditions up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day"

Constituent	Excreted in Urine per kg body wt/da		Excreted in Feces per kg body wt/da		Excreted in Sweat per 100 ml	
	Value	Range[1]	Value	Range[1]	Value	Range[1]
(A)	(B)	(C)	(D)	(E)	(F)	(G)
1 Aluminum µg	9 200	0 7 1 6	0 6	360-1,200	2 060	2 500-35 000
2 Ammonia[2] µg	0 46	4 900-18 200	35	1 116	6 0	100-5 500
3 Arsenic µg	2 900	0-1 15	7 490	5 000-10 000	0 8	30-300
4 Bromine µg	115	12 110	0 007	0 21-0 5	27	0 5-1.2
5 Calcium µg	0 07	1 100-4 910	27	0 002-0 02	200	22-45
6 Chlorine[3] mg	2.38	84-193	120	23-37	6	140-4 500
7 Cobalt µg	1 4	0 05-0 12	4 2	65-208	1.5	5-7
8 Copper µg	0 7	0-7 52	2 500	2 2 19 8		0-4 8
9 Fluorine[4] µg	0 5	6 7 100[5]	0 14	1 510-3,185		21 126
10 Iodine[6] µg	1 850	0 2 2 15	9 86	18-120		29-294
11 Iron µg	2 1	0 7 1 4	6 7	1 2 2 5		0 7 7 4
12 Lead µg	7,140	0 06-2 1	0 8	7 1 20		
13 Magnesium µg	15	950-4 500	1 7	170-450		
14 Manganese µg	34	0 095-1 4	2 0	46-500		
15 Mercury µg	1	0 007-0 01	101			
16 Nickel µg	108	2-4				
17 Nitrates µg	46	10-19				
18 Phosphorus mg	16 5	14-46				
19 Potassium mg	1	0-5 3				
20 Selenium µg	12 5	14-200				
21 Silicon µg	1 9	58-91				
22 Silver µg	4 6	4-40				
23 Sodium mg		0 6-4 5				
24 Sulfur total mg		3 5-18 25				
25 Sulfur, ethereal mg		1.0-5 0				
26 Sulfur inorganic mg		0 13-0 31				
27 Sulfur neutral mg		1-6 4				
28 Tin µg						
29 Zinc µg						

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf Introduction) /2/ See also table on excretion of nitrogen compounds /3/ Chloride /4/ Fluoride /5/ Data include regions in Texas where dental fluorosis is endemic /6/ Iodide /7/ For ages 8-12 yr

Products listed include only compounds (both diffusible and confined to the mycelium) which are produced on media containing glucose or sucrose by the more common fungi (Mucor Rhizopus Aspergillus Penicillium Alternaria Helminthosporium) The well-known antibiotics have been omitted. The organisms listed do not constitute the only species producing the compound, but rather the more common ones in many cases or those used industrially Most figures on yield are approximate as they are frequently based on weights of crude product or of pure material after losses in purification. Strains of one species may differ widely as regards yield.

	Metabolic Product	Produced By	Yield
	(A)	(B)	(C)
	Organic Acids Aldehydes Alcohols and Related Compounds		
1	Acetaldehyde	Various Penicillia, Aspergilli A. niger Mucor species and many other genera. By fixation with intercepting agents	Up to 60% of theory when grown on sucrose with Aspergillus niger
2	Acetic acid	Fomes annosus Marasmius chordalis Merulius confluens M. lachrymans M. niveus M. tremellosus	0.6% 0 9% of glucose used for Merulius lachrymans and Marasmius chordalis
3	Aconitic acid	Aspergillus niger	
4	Ascorbic acid	Aspergillus niger	0.2% of the glucose consumed.
5	Byssochlamic acid	Byssochlamys fulva.	0 5% of the glucose consumed.
6	Carlic acid	Penicillium charlesii.	Up to 1.1% of the sugar consumed.
7	Carlosic acid	Penicillium charlesii P cinerascens.	Up to 0.56% of the sugar consumed.
8	Carolic acid	Penicillium charlesii.	Up to 1.5% of the sugar consumed.
9	Carolinic acid	Penicillium charlesii.	Up to 0 9% of the sugar consumed.
10	Clavacin[1] (claviformin or patulin)	Aspergillus clavatus Penicillium expansum P claviforme P patulum.	2.2% of glucose added.
11	Clavatol	Aspergillus clavatus	Small amount.
12	Citric acid	Citromyces Penicillium luteum P citrinum P spinulosum Aspergillus niger A. clavatus A. itaconicus A. wentii Mucor pyriformis many other species. Commercial production on beet and cane molasses Submerged production possible but not yet commercially successful.	As high as 90% of theory
13	Cyclopaldic acid	Penicillium cyclopium Westling var album G Smith.	0 97% of dry mycelium.
14	Cyclopolic acid	Penicillium cyclopium Westling P cyclopium Westling var album G Smith.	5.45% of dry mycelium in P cyclopium Westling; 1.65% of dry mycelium in P cyclopium var album.
15	Dehydrocarolic acid[2]	Penicillium cinerascens	5% of the glucose consumed.
16	Dihydrogladiolic acid	Penicillium gladioli	340 mg/liter of Raulin Thom medium.
17	Dimethyl pyruvic acid	Aspergillus niger In presence of sodium sulfite as interceptor	
18	i Erythritol	Penicillium brevi-compactum P cyclopium.	0 7% of the weight of the organism.
19	Ethyl acetate	Penicillium digitatum	0 6% of the sugar consumed.
20	Ethyl alcohol	Fusarium species Mucor species Merulius species various Penicillia and Aspergilli Fomes annosus Production much slower than by yeast	Stoichiometric yield with Fusaria Merulius species Fomes annosus grown on hexoses and pentoses
21	L-Ethylene oxide α, β dicarboxylic acid	Monilia formosa n. sp. Penicillium viniferum n. sp Aspergillus fumigatus.	10-15% yield from various substrates; hexoses hexahydric alcohols pentoses pentahydric alcohol, erythritol, 2,3 butylene glycol glycerol acetate and alcohol.
22	Formic acid	Aspergillus oryzae	
23	Fumaric acid	Various species of Rhizopus; Aspergillus fumaricus Penicillium griseofulvum Caldariomyces fumago Most species other than Mucorales give small amounts	50% of theoretical yield after 30 days
24	Fumaroalanide	Penicillium resticulosum.	3 3g from 1750g glucose furnished.
25	Fumigacin[1]	Aspergillus fumigatus A. fumigatus mut. helvola	0.02 0.15% of the glucose added
26	Gentisic acid	Penicillium griseofulvum.	0.1% of the glucose consumed.
27	Gentisyl alcohol	Penicillium patulum.	2.5% of the glucose added.
28	Gladiolic acid	Penicillium gladioli.	94 mg/liter of Raulin-Thom medium.
29	Glaucic acid	Aspergillus glaucus	
30	Glauconic acid	Green Penicillium sp.	20% of a mixture.

/1/ Possesses antibiotic properties but is not in clinical use /2/ See also Carolic acid.

117 EXCRETION OF ELECTROLYTES AND MINOR MINERALS: MAN

Because of the high degree of variability in rate of sweat formation ranging from zero under some conditions up to as high as 12 liters per day in extremely hot climates it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day"

	Constituent	Excreted in Urine per kg body wt/da		Excreted in Feces per kg body wt/da		Excreted in Sweat per 100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Aluminum µg		0 7 1 6	0 6			
2	Ammonia[2] µg	9 200	4 900-18,200		360-1 200		2 500-35 000
3	Arsenic µg	0 46	0-1 15	33	1 116		
4	Bromine µg		12 110				
5	Calcium µg	2 900	1 100-4 910	7 490	5 000-10 000	2 060	100-5,500
6	Chlorine[3] mg	115	84-193		0 21-0 5		30-300
7	Cobalt µg	0 07	0 05-0 12	0 007	0 002-0 02		
8	Copper µg	2.38	0-7 52	27	23-37	6 0	
9	Fluorine[4] µg		6 7-100[5]				
10	Iodine[6] µg	1 4	0 2-2.13			0 8	0 5-1 2
11	Iron µg	0 7	0 7 1.4	120	65-208	27	22-45
12	Lead µg	0 5	0 06-2 1	4 2	2 2-19 8		
13	Magnesium µg	1 850	950-4 300	2 500	1 510-3 185	200	140-4 500
14	Manganese µg		0 095-1.4		18-120	6	5-7
15	Mercury µg		0 007-0 01	0 14			
16	Nickel µg	2.1	2-4		1 2 2 5		
17	Nitrates µg	7,140					
18	Phosphorus mg	15	10-19	9 86	7 1 20	1.5	0-4 8
19	Potassium mg	34	14-46	6 7			21 126
20	Selenium µg	1	0-3 3				
21	Silicon µg	108	14 200				
22	Silver µg						
23	Sodium mg	46	38-91				29-294
24	Sulfur total, mg	16 5	4-40				0 7 7 4
25	Sulfur ethereal mg	1	0 6-4 3				
26	Sulfur inorganic mg	12 5	3 5-18 25				
27	Sulfur neutral mg	1.9	1.0-3 0				
28	Tin µg		0 13-0 31		170-450		
29	Zinc µg	4 6	1-6 4	101	46-500		

/1/ Ranges are averages of ranges of values reported in the literature cited They may be considered to be equivalent to estimate d" of the 95% range (cf Introduction) /2/ See also table on excretion of nitrogen compounds /3/ Chloride /4/ Fluoride /5/ Data include regions in Texas where dental fluorosis is endemic /6/ Iodide /7/ For ages 8-12 yr

Products listed include only compounds (both diffusible and confined to the mycelium) which are produced on media containing glucose or sucrose by the more common fungi (Mucor Rhizopus Aspergillus Penicillium Alternaria Helminthosporium) The well-known antibiotics have been omitted. The organisms listed do not constitute the only species producing the compound, but rather the more common ones in many cases or those used industrially Most figures on yield are approximate as they are frequently based on weights of crude product or of pure material after losses in purification. Strains of one species may differ widely as regards yield.

	Metabolic Product (A)	Produced By (B)	Yield (C)
	Organic Acids Aldehydes Alcohols and Related Compounds		
1	Acetaldehyde	Various Penicillia Aspergilli A. niger Mucor species and many other genera. By fixation with intercepting agents	Up to 60% of theory when grown on sucrose with Aspergillus niger
2	Acetic acid	Fomes annosus Marasmius chordalis Merulius confluens M. lacrymans M. niveus M. tremellosus	0 6% 0.9% of glucose used for Merulius lacrymans and Marasmius chordalis
3	Aconitic acid	Aspergillus niger	
4	Ascorbic acid	Aspergillus niger	0 8% of the glucose consumed.
5	Byssochlamic acid	Byssochlamys fulva.	0 5% of the glucose consumed.
6	Carlic acid	Penicillium charlesii.	Up to 1.1% of the sugar consumed.
7	Carlosic acid	Penicillium charlesii P cinerascens	Up to 0 36% of the sugar consumed.
8	Carolic acid	Penicillium charlesii	Up to 1.5% of the sugar consumed.
9	Carolinic acid	Penicillium charlesii	Up to 0 9% of the sugar consumed.
10	Clavacin[1] (claviformin or patulin)	Aspergillus clavatus Penicillium expansum, P claviforme P patulum.	2.8% of glucose added.
11	Clavatol	Aspergillus clavatus	Small amount.
12	Citric acid	Citromyces Penicillium luteum P citrinum P spinulosum, Aspergillus niger A. clavatus A. itaconicus A. wentii Mucor pyriformis many other species Commercial production on beet and cane molasses. Submerged production possible but not yet commercially successful.	As high as 90% of theory
13	Cyclopaldic acid	Penicillium cyclopium Westling var album G Smith.	0 97% of dry mycelium.
14	Cyclopolic acid	Penicillium cyclopium Westling P cyclopium Westling var album G. Smith.	3.45% of dry mycelium in P cyclopium Westling; 1.65% of dry mycelium in P cyclopium var album.
15	Dehydrocarolic acid[2]	Penicillium cinerascens.	3% of the glucose consumed.
16	Dihydrogladiolic acid	Penicillium gladioli.	340 mg/liter of Raulin Thom medium.
17	Dimethyl pyruvic acid	Aspergillus niger In presence of sodium sulfite as interceptor	
18	i-Erythritol	Penicillium brevi-compactum P cyclopium.	0 7% of the weight of the organism.
19	Ethyl acetate	Penicillium digitatum	0 6% of the sugar consumed.
20	Ethyl alcohol	Fusarium species Mucor species Merulius species various Penicillia and Aspergilli Fomes annosus Production much slower than by yeast.	Stoichiometric yield with Fusaria, Merulius species Fomes annosus grown on hexoses and pentoses
21	L-Ethylene oxide α, β dicarboxylic acid	Monilia formosa n. sp. Penicillium viniferum n. sp. Aspergillus fumigatus	10-15% yield from various substrates; hexoses hexahydric alcohols pentoses pentahydric alcohol, erythritol 2,3, butylene glycol glycerol acetate and alcohol.
22	Formic acid	Aspergillus oryzae.	
23	Fumaric acid	Various species of Rhizopus; Aspergillus fumaricus Penicillium griseofulvum Caldariomyces fumago. Most species other than Mucorales give small amounts	50% of theoretical yield after 30 days
24	Fumaroalanide	Penicillium resticulosum.	3 3 g from 1750 g glucose furnished.
25	Fumigacin[1]	Aspergillus fumigatus A. fumigatus mut. helvola	0.02 0 13% of the glucose added.
26	Gentisic acid	Penicillium griseofulvum.	0 1% of the glucose consumed.
27	Gentisyl alcohol	Penicillium patulum.	2.3% of the glucose added.
28	Gladiolic acid	Penicillium gladioli	94 mg/liter of Raulin-Thom medium.
29	Glaucic acid	Aspergillus glaucus	
30	Gluconic acid	Green Penicillium sp.	80% of a mixture.

/1/ Possesses antibiotic properties but is not in clinical use /2/ See also Carolic acid.

	Metabolic Product (A)	Produced By (B)	Yield (C)
	Organic Acids Aldehydes Alcohols and Related Compounds (cont'd)		
31	Gluconic acid	Penicillium chrysogenum P luteum P purpurogenum Aspergillus species Fusarium lini Bolley	Practically quantitative conversion in 24 hours
32	Glucose	Aspergillus niger From tartaric acid lactic acid mannitol and quinic acid.	
33	Glucosone	Aspergillus parasiticus A. flavus	5% from glucose 13-17% from sucrose maltose starch
34	Glutaconic acid	Aspergillus niger strains	
35	Glutaric acid	Aspergillus niger strains	
36	Glycerol	Mucor racemosus Aspergillus wentii white Aspergilli Clasterosporium and Helminthosporium.	Usually small amounts; some species 5% of the glucose consumed.
37	Glycolic acid	Aspergillus niger (from acetate)	Traces
38	Glycuronic acid	Ustulina vulgaris	
39	Glyoxylic acid	Aspergillus niger (from acetate) Merulius lacrymans	Traces
40	2-Hydroxymethyl furane 5-carboxylic acid	Aspergillus glaucus A. clavatus A. niger A. oryzae A. wentii	
41	Itaconic acid	Aspergillus terreus A. itaconicus	As high as 50% of theoretical yield
42	Itatartaric acid	Aspergillus terreus mutant	1.5% of glucose added.
43	γ-Ketopentadecoic acid	Penicillium minio-luteum P spiculisporum.	2.5% of the glucose consumed.
44	Kojic acid	Aspergillus flavus oryzae tamarii group A. wentii	45-55% in 12 days 63-66% reported.
45	D-Lactic acid	Practically confined to Mucorales Various Rhizopus species i R. stolonifer oryzae japonicus tritici arrhizus Fumaric acid produced by altering conditions	Up to 60% with R. oryzae 39-40% with R. japonicus
46	Malic acid	White species f Aspergillus A. flavus Clasterosporium sp Accompanied by succinic and fumaric acids	Fair yi lds by submerged growths when growing at low temperature
47	Malonic acid	Penicillium funiculosum.	
48	Mannitol	White species of Aspergillus many Aspergilli Byssochlamys fulva Penicillium griseofulvum. Not produced from fructose	45-50% of theory
49	Mannonic acid	Penicillium purpurogenum var rubrisclerotium. On D-mannose Certain Aspergillus niger strains On mannose Certain A. niger strains On galactose	9% yield. 70% yield High yield
50	Mellein[3] (ochracin)	Aspergillus melleus A. ochraceus	300 mg/l of medium on sucrose
51	Methyl glyoxal	Aspergillus niger On hexosediphosphate	16% of the substrate consumed.
52	Methyl salicylic acid	Penicillium griseofulvum P flexuosum	2 4% of the glucose consumed.
53	γ-Methyl tetronic acid	Penicillium charlesii	Up to 0 92% of the sugar consumed.
54	Minioluteic acid[4]	Penicillium minio-luteum	2 5% of the glucose consumed
55	Mycophenolic acid	Penicillium brevi-compactum, P stoloniferum.	0 95% of the glucose consumed
56	Oxalic acid	Citromyces Aspergillus Penicillium and many other genera. Can be produced more economically by other methods	50% of the sugar consumed
57	Palitantin	Penicillium palitans	About 1% of the glucose consumed.
58	Penicillic acid[1]	Penicillium cyclopium P puberulum Aspergilli.	4 2% of the glucose consumed.
59	Penicillium brevicompactum acids I	Penicillium brevi-compactum	0 9% of the sugar consumed.
60	Penicillium brevicompactum acids: II	Penicillium brevi-compactum	0 1% of the sugar consumed.
61	Penicillium brevicompactum acids: III	Penicillium brevi-compactum	0 9% of the sugar consumed.
62	Penicillium brevicompactum acids: IV	Penicillium brevi-compactum	0 05% of the sugar consumed.
63	Propionic acid	Botrytis cinerea. On lactate	
64	Puberulic acid[5]	Penicillium puberulum.	0 66% of the glucose consumed. (crude)
65	Puberulonic acid[5]	Penicillium puberulum.	
66	Pyruvic acid	Aspergillus niger (i presence of sodium sulfite as interceptor) Fumaria.	8 2% of the glucose consumed.

/1/ Possesses antibiotic properties but is not i clinical use /3/ Converted to methyl salicylic acid on KOH fusion. /4/ Related to spiculisporic acid. /5/ Tropolone derivative

118 PRODUCTS OF CARBOHYDRATE METABOLISM: MOLDS (Continued)

	Metabolic Product	Produced By	Yield
	(A)	(B)	(C)
	Organi Acids Aldehydes Alcohols and Related Compounds (concluded)		
67	Saccharic acid	Aspergillus niger	
68	Sorbicillin	Penicillium notatum.	
69	Spiculisporic acid[6]	Penicillium spiculisporum P crateriforme P minio-luteum.	Approx. 8% of th sugar utilized.
70	Stipitati acid[5]	Penicillium stipitatum.	Up to 5% of the sugar consumed.
71	Succinic acid	Mucor stolonifer Aspergillus terreus Ustilina vulgaris Penicillium aurantio-virens P spi culosporum Fusarium oxysporum heterosporum and lini Bolley Fomes annosus Merulius con fluens M. niveus M. tremellosus	Yields very small except for Fusarium species
72	Sulochrin	Oospora sulphureo-ochracea.	5% of th mycelium.
73	Terrein	Aspergillus terreus	(crude) 2 5% of the glucose consumed.
74	Terrestric acid (ethyl caroli acid)	Penicillium terrestre	2.4% of the sugar consumed.
75	Ustic acid	Aspergillus ustus	0 6% of glucose added.
	Pigments		
76	Alboleersin (colorless)[7]	Helminthosporium leersii	? 4% of mycelial weight
77	Aurofusarin	Fusarium culmorum F graminearum.	Up to 4 4% of mycelial weight
78	Auroglaucin	Aspergillus glaucus sp.	More than 15% of the dry growth.
79	β-Carotene	Neurospora Mucor hiemalis Phycomyces blakesleeanus	Traces
80	γ-Carotene	Allomyces species	Traces
81	Carviolacin	Penicillium roseopurpureum (P carminoviolaceum)	3 0% of mycelium (crude pigment)
82	Carviolin	Penicillium roseopurpureum (P carminoviolaceum)	3 0% of mycelium (crude pigment)
83	Catenarin[8] (1-hydroxy emodin)	Helminthosporium catenarium H. gramineum, H. velutinum H. tritici-vulgari	As much as 10% 40% of the mycelial weight in Helminthosporium gramineum, 20% in H. catenarium.
84	Chrysogenin	Penicillium chrysogenum.	
85	Chrysophani acid (chrysophanol)	Penicillium islandicum.	0.1% of dried mycelium.
86	Citrinin[1]	Penicillium citrinum Aspergillus terreus.	5 4% of the sugar consumed.
87	Citromycetin	Citromyces glaber (Penicillium frequentans group)	As much as 20% sugar metabolized.
88	Culmorin (colorless)	Fusarium culmorum F graminearum.	Up to 4 6½% of the mycelium. Isolated along with aurofusarin.
89	Cynodontin[8]	Helminthosporium cynodontis H. euchlaenae H. avenae	Up to 4 2% of mycelium
90	Emodi acid	Penicillium cyclopium.	0 1% (as acetyl derivative) of glucose supplied.
91	Ergochrysin	Sclerotium clavus.	
92	Ergoflavin	Sclerotium clavus.	
93	Erythroglaucin	Aspergillus glaucus group 15 species	0 25% of the mycelium (pure)
94	Flavoglaucin	Aspergillus glaucus	More than 25% f the dry growth weight.
95	Fulvi acid	Penicillium griseofulvum, P flexuosum, P brefeldianum.	15-20% of the mycelium 2 7% of the glucose consumed.
96	Fumigatin	Aspergillus fumigatus	0 35% of the glucose consumed (crude material)
97	Funiculosin (trihydroxy-methyl-anthraquinone)	Penicillium funiculosum.	
98	Fusarubin	Fusarium solani	On sucrose 25 mg/liter of medium.
99	Helminthosporin[7]	Helminthosporium gramineum H. catenarium H. tritici-vulgaris H cynodontis	As much as 22% 40% of the mycelial weight in H. gramineum.
100	ω-Hydroxy emodin	Penicillium cyclopium P citreo-roseum P cyaneo-fulvum.	0 1/ of glucose (tetraacetyl derivative) supplied.
101	3-hydroxy-4 methoxy toluquinol[9]	Aspergillus fumigatus	
102	Islandicin	Penicillium islandicum.	5% of the mycelium.
103	Javanicin	Fusarium javanicum.	0 07% of the glucose added (pure)
104	Luteoleersin[10]	Helminthosporium leersii	1.8% of the mycelium.

/1/ Possesses antibioti properties but is not in clinical use /5/ Tropolone derivative /6/ Related to minioluteic acid. /7/ Related to luteoleersin. /8/ Compare items no 83 89 99 and 125 Different species of Helminthosporium have different proportions of these pigments /9/ Reduced form of fumigatin. /10/ Related to alboleersin.

	Metabolic Product	Produced By	Yield
	(A)	(B)	(C)
	Pigments (concluded)		
105	Lycopersin	Fusarium lycopersici	
106	Monascoflavin	Monascus purpureus	
107	Monascorubrin	Monascus purpureus	
108	Malgiovensin	Penicillium malgiovensis	1% of dry mycelium.
109	Oosporein	Oospora colorans	9 5% of the substrate added.
110	Oxy javanicin	Fusarium javanicum.	0.02% of the glucose added (pure)
111	Penatrinic acid	Penicillium notatum.	
112	Penicilliopsin	Penicilliopsis clavariaeformis	7 5% of the mycelium.
113	Phoenicin	Penicillium phoeniceum P rubrum (Also Bacillus pyocyaneus)	1.2% (pure) of mycelium.
114	Physcion (Emodin monomethyl ether)	Aspergillus glaucus species	0.65% of the mycelium (pure)
115	Physcion anthranol A (4 5 dihydroxy-7-methoxy 2-methyl-9-anthranol)	Aspergillus glaucus	Very small amount.
116	Physcion anthranol B (4 5 dihydroxy 7-methoxy-2 methyl 10-anthranol)	Aspergillus glaucus.	Very small amount
117	Ravenelin	Helminthosporium ravenelii H. turcicum.	10% of the mycelium.
118	Rubrofusarin	Fusarium culmorum F graminearum.	Up to 1.15% of mycelial weight Crude pigment up to 8 7% of mycelial weight
119	Rugulosin	Penicillium rugulosum.	
120	Solanione	Fusarium solani D_2 purple	
121	Spinulosin (6-hydroxy fumigatin)	Penicillium spinulosum F cinerascens Aspergillus fumigatus	0.11% of the glucose consumed (A. fumigatus)
122	Tetrahydrophoenicin (leucophoenicin)	Penicillium rubrum.	
123	Tritisporin[8]	Helminthosporium tritici vulgaris Helminthosporium species	1.4% of the mycelium.
	Chlorine containing Compounds		
124	Caldariomycin	Caldariomyces fumago.	0.4% of the glucose consumed
125	Erdin[11]	Aspergillus terreus.	0.6% of the sugar consumed.
126	Geodin[11]	Aspergillus terreus	0.6% of the sugar consumed.
127	Griseofulvin[1]	Penicillium griseofulvum, P janczewskii	2% of the mycelium.
128	Malgiolarin[12]	Penicillium malgiovensis	0.18% of dry mycelium.
129	Sclerotiorine	Penicillium sclerotiorum.	2% of the mycelium.
	Polysaccharides		
130	Capreolinose[13]	Penicillium capreolinum.	
131	Glycogen[14] (red-brown I_2 color)	White species of Aspergillus Penicillium digitatum.	
132	Gums	Oidium sp. Penicillium lactis P guttulosum Monilia candida Mucor racemosus	30% on 10% mannose
133	Levan[15]	Aspergillus sydowii	(from sucrose only)
134	Luteic acid (Lutose)[16]	Penicillium luteum.	10-12%.
135	Mold starch[14] (blue I_2 color)	Penicillium species	
136	Mycodextran[14] (no I_2 color)	Penicillium expansum, Aspergillus niger	2% of the growth.
137	Mycogalactan[17]	Aspergillus niger (produced along with Mycodextran).	
138	Polygalactose[17] (galactocarolose)	Penicillium charlesii	Approx. 5% of the sugar consumed. (crude)
139	Polymannose[18]	Penicillium charlesii	Approx. 4% sugar consumed (crude)
140	Rugulose[17]	Penicillium rugulosum	
141	Sclerotiose[14]	Penicillium sclerotiorum.	10% of the mycelial weight

/1/ Possesses antibiotic properties but is not in clinical use /8/ Compare items no 85 89 99 and 123 Different species of Helminthosporium have different proportions of these pigments /11/ Geodin and erdin are closely related compounds /12/ Mono-chloro-malgiovensin. /13/ Hydrolysis yields mannose glucose galactose and mannonic acid. /14/ Hydrolysis yields glucose /15/ Hydrolysis yields fructose /16/ Hydrolysis yields D-glucose-malonic acid (1:1) demalonylated luteic acid. /17/ Hydrolysis yields galactose /18/ Hydrolysis yields mannose

118 PRODUCTS OF CARBOHYDRATE METABOLISM MOLDS (Concluded)

Metabolic Product	Produced By	Yield
(A)	(B)	(C)
	Polysaccharides (concluded)	
142 Varianose[19]	Penicillium varians	Approx. 1% of the glucose consumed (crude material)
	Sterols and Lipids	
143 Cerebrin	Aspergillus sydowii	0.1-0 4%
144 Cerebronylsphingosine compounds	Aspergillus citromyces	
145 Ergosterol	Aspergillus niger A. oryzae Fusarium lycopersici F lini Bolley Helminthosporium avenae H. ravenelii H. velutinum Lentinus lepideus Penicillium expansum P puberulum.	0 13% 1 7% of mycelium.
146 Ergosteryl palmitate	Penicillium brevi-compactum, P italicum.	0 5% of the growth 0 6% of the glucose consumed.
147 Fat	All organisms.	Various
148 Lecithin	Aspergillus oryzae (spores)	
149 Lecithin and cephalin	Aspergillus sydowii.	0 45-0 73%
150 Phosphatides	Aspergillus oryzae A. sydowii A. citromyces	
151 Sterols	Aspergillus fischeri Penicillium puberulum Paecilomyces varioti Fusaria	0 13%-1.0% of the dry mycelium.
	Nitrogen Containing Compounds	
152 Adenine	Aspergillus niger	0.03%
153 Aspergilli acid	Aspergillus flavus.	1% of the carbohydrate added.
154 Betaine	Aspergillus oryzae (spores)	
155 Choline sulphate	Aspergillus sydowii (from hydrolysis of mycelium)	
156 Hypoxanthine	Aspergillus oryzae Rhizopus japonicus	
157 Lycomarasmin (asparagyl glycylhydroxyalanine)	Fusarium lycopersici	110 mg/1 of medium on glucose
158 Stachydrine (n-methyl proline-methyl betaine)	Aspergillus oryzae Rhizopus japonicus	
159 Thiamine	Fusarium lini Bolley	20 gammas/gram of mycelium.
160 Urea	Penicillium johannioli Aspergillus niger Rhizopus nigricans	
161 Uri acid	Aspergillus oryzae (spores)	

/19/ Hydrolysis yields D-glucose D-galactose and D-idose or L-altrose

119 PRODUCTS OF CARBOHYDRATE METABOLISM AS AFFECTED BY CHANGE IN pH YEASTS AND BACTERIA

Values represent mM of product per 100 mM glucose fermented Higher values have been rounded to nearest whole number

	Organism and pH[1] →	Bacillus subtilis		Aerobacter aerogenes		Serratia marcescens		Escherichia coli		Saccharomyces cerevisiae	
	Product	pH 6.2	pH 7 6	pH 6 0	pH 8 0	pH 6 4	pH 7 8	pH 6 0	pH 7 8	pH 3 0	pH 7 6
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Acetic acid	1.2	12 8	8 0	53	1 9	49	36	39	0 5	15 1
2	Acetoin	2 7	3 0	1 6	5 8	1 6	5 9	0 1	0.2	0	0 2
3	2,3-Butanediol	40	11.8	48	0	55	0	0 3	0 3	0 8	0 7
4	CO_2	86	52	174	19 6	116	2.2	88	1 7	181	149
5	Ethanol	15 1	22 3	57	61	47	41	50	50	172	130
6	Formic acid	16 6	40	0 8	120	46	91	2 4	86	0 4	0 5
7	Glycerol	31	10 3	3 3	6 6	2.2	9 6	1 4	0 3	6.2	32
8	H_2	0 5	0 3	74	10 4	0 8	0.2	75	0 3		
9	Lactic acid	66	119	3.4	9 8	9 7	65	80	70	0 8	1.4
10	Succinic acid	0 7	2.2	1.8	9 3	2 9	4 8	10 7	14 8	0 5	0 7

/1/ The pH was electronically controlled using ammonium hydroxide to neutralize the acids formed

120 PRODUCTS OF CARBOHYDRATE METABOLISM OF INDUSTRIAL IMPORTANCE BACTERIA

	Main Product	Organism	Raw Materials (Substrate)	Conditions
	(A)	(B)	(C)	(D)
1	Acetone, butanol	Clostridium acetobutylicum, etc	Molasses, corn, starches	pH 5-7, 37-40 C, 48-78 hours
2	Butylene glycol[1]	Aerobacter aerogenes, Bacillus polymyxa and certain other aerobic bacilli	Grains, molasses, starches	pH 5-6 5, 30 C, 3-4 days
3	Dextran	Leuconostoc mesenteroides	Sucrose	
4	Lactic acid	Lactobacillus delbrueckii and other species; Streptococcus lactis, etc	Molasses whey	pH 7, 40-50 C[2] 42 hours
5	l-Sorbose	Acetobacter suboxydans	d-Sorbitol	28 C, 14-45 hours

/1/ Has been produced on a pilot-plant scale; industrial production practicable but not in progress /2/ The temperature depends on the bacterial species used

121 METABOLIC PRODUCTS OF BACTERIA: ANAEROBIC FERMENTATION OF GLUCOSE

Ten groups of organisms are represented, each by a single member of the group. All members in a group produce from glucose the same compounds in similar proportions. All members of a single group are therefore classified as belonging to the same fermentation type". Values are mM of the metabolic product per 100mM glucose fermented

Product \ Species	Streptococcus lactis (Simple lactic)	Lactobacillus brevis (Mixed lactic)	Propionibacterium petersoni (Propionic)	Escherichia coli (Colon group, type I)	Aerobacter aerogenes (Colon group type II)	Eberthella typhi (Colon group, type III)	Clostridium saccharobutyricum (Butyric)	C acetobutylicum (Butyl)	C butylicum (Isopropyl)	Aeromonas hydrophila (Butylene glycol)
	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1 Carbon dioxide		87	51 6	50	178		196	220	297	166
Hydrogen				39	49		235	166	73	57
Acids:										
Formic				0 9	21 2	39				
4 Acetic		17 5	54	29		26	43	25	21 2	4 6
Propionic			140							
Butyric							75	7 1	6 1	
Lactic	192	73		109		122				23 3
Succinic			11 4	15 9		10 8				3 6
Alcohols:										
c Ethyl		75		42	67	25		4 9		52
1C Isopropyl									15 1	
11 Butyl								47	67	
1 Glycerol		39								
1 Acetyl-methyl carbinol					16 4			5 7		1 7
14 Butylene glycol					63					54 7
1 Acetone								22 3		

122 OXYGEN CONSUMPTION: BLOOD FORMED ELEMENTS MARROW, SPLEEN LYMPH NODES THYMUS

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient $-Q_{O_2}$) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at ±37° C The decrease in amount of gaseous O_2 as it is used by the tissue is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	Q_{O_2}
	(A)	(B)	(C)
1	Marrow bone erythroid cells rabbit	Serum	9 0
2	Marrow bone myeloid cells rabbit	Serum	6 0
3	Leucocytes human, normal	Heparinized plasma	6.9
4	Leucocytes goose	Citrated plasma glucose	4 4
5	Leucocytes rabbit exudat	Citrated Ringer solution	4 0-4 6
6	Leucocytes rabbit [illegible]	Serum	7 0
7	Leucocytes rat	Serum	9 0-9.2
8	Nodes lymph, human	Ringer glucose	3 8-3 9
9	Nodes lymph rat	Ringer glucose	4 4
10	Plat lets human	Citrated plasma glucose	6.2-8 4
11	Platelets dog	Citrated plasma glucose	5 1
12	Platelets rat	Serum	6 0
13	R B C human	Ringer glucose	0 043
14	R B C horse	Ringer glucose	0 06
15	R B C rabbit	Saline	0 008
16	R B C rabbit	Serum	0 093
17	R B C rat	Ringer glucose	0 058
18	R B C (nucleated) chicken	Saline; Ringer glucose	0 14
19	R B C (nucleated) chicken	Serum	0 30
20	R B C (nucleated) goose	Serum	0 58-1 79
21	R B C (nucleated), turtle	Saline	0 05
22	Reticulocytes rabbit	Ringer glucose	0 25
23	Reticulocytes rabbit	Serum	1 75
24	Spleen, guinea pig	Saline	8 15
25	Spleen, rat	Ringer glucose	7 2 12 9
26	Spleen rat	Serum	13 0
27	Thymus rat	Ringer glucose	3 5-5.8
28	Tonsil, human	Ringer glucose	5 1

123 OXYGEN CONSUMPTION: EPITHELIUM AND ASSOCIATED TISSUES

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient Q_{O_2}) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at ±37° C The decrease in amount of gaseous O_2 as it is used by the tissue, is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue glucose or other nutrient may be added to the medium

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Mucosa colon rabbit	Ringer glucose; serum	11 1
2	Mucosa colon rat	Ringer glucose	3 4-14 6
3	Mucosa duodenal rat	Ringer glucose	8 8
4	Mucosa gastric, human	Ringer glucose	9 6
5	Mucosa gastric rat	Ringer glucose	7.2
6	Mucosa ileum, rat	Ringer glucose	3 7
7	Mucosa, intestinal rat	Ringer glucose	9 4-23 3
8	Mucosa jejunal, rat	Ringer glucose	12 4
9	Mucosa, uterine, rabbit	Serum	6 1
10	Skin human, fetus	Ringer phosphate	1 8
11	Skin human, adult	Ringer glucose	2 1
12	Skin, guinea pig	Ringer glucose	3 0
13	Skin mouse, newborn	Ringer glucose	6 1
14	Skin, rat newborn	Ringer glucose	3 3
15	Skin rat 10-36 da	Ringer glucose	4 9-3 6[1]
16	Skin rat 79 da, adult	Ringer glucose	1 8-1 2[1]

/1/ Range shows a decrease with age

124 OXYGEN CONSUMPTION GLAND TISSUES

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient -Q_{O_2}) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at ±37° C The decrease in amount of gaseous O_2, as it is used by the tissue is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	Q_{O_2}
	(A)	(B)	(C)
1	Adrenal, guinea pig	Serum	6 0
2	Mouse	Serum	6 0
3	Rat	Serum	10 0
4	Pancreas cat	Ringer glucose	5 8
5	Dog	Ringer glucose	3.2
6	Guinea pig	Saline	2 7
7	Pigeon	Saline	8 7
8	Rabbit	Ringer glucose	4.6
9	Rat	Saline	5 7
10	Rat	Ringer glucose	5.2
11	Pituitary mouse	Serum	8 0
12	Rat young	Serum	12 0
13	Rat anterior pituitary	Ringer glucose	5 9
14	Rat, posterior pituitary	Ringer glucose	6.6
15	Salivary gland, human	Ringer glucose	6 3
16	Cat acetylcholine stimulation	Ringer glucose	13 6
17	Cat eserine plus ACh	Ringer glucose	22 7
18	Cat, resting	Ringer glucose	10 3
19	Dog	Ringer glucose	10 6
20	Guinea pig	Saline	5 0
21	Rat	Ringer glucose	11 6-16 6
22	Thyroid, calf	Ringer glucose	2 6
23	Dog	Serum	9.1
24	Dog	Ringer glucose	2 0
25	Dog	Ringer glucose	2 1
26	Rabbit	Ringer glucose serum	11 7
27	Rat	Ringer glucose	12 5-13 0

125 OXYGEN CONSUMPTION LUNG

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, -Q_{O_2}) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C The decrease in amount of gaseous O_2, as it is used by the tissue, is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Species	Medium	-Q_{O_2}
	(A)	(B)	(C)
1	Cat	Ringer glucose	3 9
2	Guinea pig	Ringer glucose	6 1
3	Guinea pig	Saline	7 4
4	Human embryo	Ringer glucose	3 7
5	Mouse	Ringer glucose	7 3-8 0
6	Pigeon	Ringer glucose	3 6
7	Rabbit	Ringer glucose	6 7
8	Rat, adult	Saline	7 9
9	Rat, adult	Ringer glucose	4 4-7 8
10	Rat, embryo	Serum	10 0

126 OXYGEN CONSUMPTION: LIVER

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient Q_{O_2}) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C The decrease in amount of gaseous O_2 as it is used by the tissue is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium

	Species	Medium	Q_{O_2}
	(A)	(B)	(C)
1	Chick embryo, 6 da	Ringer glucose	7 5
2	Chick embryo, 12 da	Ringer glucose	4 3
3	Chick embryo, 20 da	Ringer glucose	1.5
4	Cow	Ringer glucose	2 6
5	Dog	Ringer glucose	6 0
6	Guinea pig	Saline	8 1
7	Guinea pig	Ringer solution	5 0
8	Guinea pig fatty liver	Ringer solution	7 4
9	Hen	Serum	14 5
10	Horse	Ringer glucose	2 1
11	Mouse	Ringer solution	18 7
12	Mouse	Ringer glucose	8 8-13 8
13	Rabbit	Ringer glucose	4 2-7 7
14	Rat fetus	Serum, Ringer glucose	7 1
15	Rat, young, 3-21 da	Ringer glucose	13 2
16	Rat, adult	Ringer solution	9 8-10 2
17	Rat, adult	Ringer glucose	6 5-11.6
18	Sheep	Ringer glucose	2 5

127 OXYGEN CONSUMPTION: MISCELLANEOUS TISSUES, COMPARATIVE

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C The decrease in amount of gaseous O_2, as it is used by the tissue, is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium

	Species	Q_{O_2} [1]				
		Brain Cortex	Kidney Cortex	Liver	Spleen	Lung
	(A)	(B)	(C)	(D)	(E)	(F)
1	Cat	26 9	22 7	13 2	8 4	3 9
2	Cattle	17.2	23 5	8 2	4 4	4 3
3	Dog	21 2	27 0	11 7	6 6	4 9
4	Guinea pig	27 3	31 8	13 0	11 6	8 5
5	Horse	15 7	21 5	5 4	4 2	4 4
6	Mouse	32 9	46 1	23 1	16 9	12 0
7	Rabbit	28 2	34 5	11 6	14 2	8 0
8	Rat	26 3	38 2	17 2	12 7	8 6
9	Sheep	19 7	27 5	8 5	6 9	5 4

/1/ The medium used for the determination of the $-Q_{O_2}$ values was essentially a calcium free, Ringer-phosphate solution but containing pyruvate (or lactate), fumarate, glutamate and glucose

128. OXYGEN CONSUMPTION: MISCELLANEOUS TISSUES, IN THE PRESENCE OF VARIOUS SUBSTRATES

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient Q_{O_2}) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at ±37° C The decrease in amount of gaseous O_2 as it is used by the tissue is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue glucose or other nutrient may be added to the medium.

	Animal and Tissue	Nutrient Added	Q_{O_2}
	(A)	(B)	(C)
1	Brain[1] rat	None added	2 9
2		Glucose	10 8
3		Glutamate	8 0
4		Lactate	13 6
5		Succinate	9 5
6	Diaphragm rat	None added	6 3[2]
7		Glucose	5 4
8		Lactate	9 4[3]
9		Pyruvate	6 3[4]
10	Heart dog	None added	2.6
11		Glucose	2 7
12		Lactate	4 6
13		Pyruvate	6 3
14	Kidney rat	None added	15 8[5]
15		Alanine	38
16		Butyrate	23 2
17		Glucose	23 1[6]
18		Lactate	34
19		Pyruvate	26
20	Liver rat	None added	7 2[7]
21		Butyrate	8 1
22		Glucose	9 0
23		Lactate	10 7
24		Succinate	26
25	Skeletal muscle strips, dog	None added	1.2
26		Glucose	1.5
27		Lactate	1.7

/1/ Cerebra. co te /2/ Value of also reporte

129 OXYGEN CONSUMPTION: MUSCLE

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, Q_{O_2}) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at ±37° C The decrease in amount of gaseous O_2, as it is used by the tissue is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium

	Animal and Tissue	Medium	Q_{O_2}
	(A)	(B)	(C)
1	Diaphragm, dog young	Ringer glucose	1 9
	Diaphragm, rabbit	Ringer glucose	2 4
	Diaphragm, rat	Saline Ringer sol	4 1 5 9
4	Diaphragm, rat	Serum	5 9
	Heart cat	Ringer glucose	2 5
6	Heart chick embryo, 4 da	Serum	30
	Heart chick embryo 6-7 da	Serum	14 9
	Heart, dog, juvenile	Ringer glucose	4.2
c	Heart dog	Ringer glucose	2 6
1C	Heart, rat	Ringer glucose	3 8-10 4
11	Muscle skeletal frog resting	Ringer glucose	0 18-0 24
1	Muscle skeletal frog electrical stimulation	Ringer solution	0 79-4 24
1	Muscle skeletal pigeon	Saline	2 1
1l	Muscle skeletal rat	Ringer glucose	2 5-5 1
1	Muscle smooth gastric human	Ringer glucose	1 3
1ℓ	Muscle smooth gastric rat	Ringer glucose	3 5
1	Muscle, smooth intestinal cat	Ringer glucose	1 4
1ℓ	Muscle smooth intestinal frog	Ringer glucose	0 28
1	Muscle, smooth intestinal, rabbit	Ringer glucose	2 6
2(	Muscle smooth intestinal, rat	Saline	7 1
1	Muscle Smooth Intestinal, rat	Ringer glucose	6 5

130 OXYGEN CONSUMPTION: NEOPLASMS BENIGN AND HYPERPLASTIC TISSUE

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient Q_{O_2}). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at 37° C. The decrease in amount of gaseous O_2 as it is used by the tissue is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	Q_{O_2}
	(A)	(B)	(C)
1	Goiter colloid, resting, human	Ringer glucose	2 5-5.2
2	Goiter hyperactive human	Ringer glucose	12 3
3	Heart fibroblasts[1] 1 transfer	Serum glucose	22 3
4	Heart fibroblasts[1] 3-8 transfers	Serum glucose	12 8
5	Heart fibroblasts[1] 3000 transfers	Serum glucose	12 0
6	Papilloma bladder human	Ringer glucose	8 5-13 0
7	Polyp nasal human	Ringer glucose	4 1 5 0
8	Tonsil hyperplastic human	Ringer glucose	6 6-14 7
9	Wart skin human	Ringer glucose	1 5

/1/ In tissue culture young chicken

131 OXYGEN CONSUMPTION: NEOPLASMS, MALIGNANT

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient Q_{O_2}). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at 37° C. The decrease in amount of gaseous O_2 as it is used by the tissue is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	Q_{O_2}
	(A)	(B)	(C)
1	Adenocarcinoma mouse	Ringer glucose	6 1-26
2	Carcinoma, Flexner-Jobling, rat	Ringer solution, Ringer glucose	6 0-8 6
3	Carcinoma various human	Ringer glucose	2 0-7 9
4	Carcinoma, various mouse	Ringer glucose	11.1-18 8
5	Leukocytes human myelogenic leukemia	Heparinized plasma	8 6
6	Leucocytes human lymphatic leukemia	Heparinized plasma	6 5
7	Leucocytes human, lymphatic leukemia	Citrated plasma glucose	5 8
8	Sarcoma, Crocker mouse	Ringer glucose	9 7 14 8
9	Sarcoma, Jensen, rat	Ringer glucose	9.2 14 4
10	Sarcoma, Rous chick	Ringer glucose	4 6-12.1
11	Sarcoma, Rous chick	Serum	6 0
12	Sarcoma, various mouse	Ringer glucose	8 5-15 3
13	Tumor spontaneous chick	Ringer glucose	7 5-8.8

132 OXYGEN CONSUMPTION NERVE TISSUE INCLUDING RETINA

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C The decrease in amount of gaseous O_2, as it is used by the tissue, is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Brain, chick embryo	Serum	25
2	Cerebral cortex, man	Ringer glucose	6 0-10 3
3	Cerebral cortex, cat	Ringer glucose	8 5-12 2
4	Cerebral cortex, dog	Ringer glucose	6 7
5	Cerebral cortex, guinea pig	Saline	6 9
6	Cerebral cortex guinea pig	Saline glucose	11 7
7	Cerebral cortex, monkey	Ringer glucose	7 4-11 8
8	Cerebral cortex mouse	Ringer solution	11 0
9	Cerebral cortex pig 29-60 da fetus	Ringer solution	5 5
10	Cerebral cortex pig 99 da fetus	Ringer solution	6 5
11	Cerebral cortex, pig birth to adult	Ringer solution	8 5
12	Cerebral cortex, pigeon	Saline glucose	14 6
13	Cerebral cortex rabbit	Ringer glucose	7 3-10 4
14	Cerebral cortex rat 5 da	Ringer glucose	6 2
15	Cerebral cortex rat 50 da	Ringer glucose	14 7
16	Cerebral cortex rat adult	Ringer glucose	8 5-17 1
17	Ganglion, celiac rabbit	Serum	4 0
18	Ganglion dorsal root, rat	Ringer solution	8 0
19	Ganglion trigeminal sheep	Ringer solution	0 5
20	Hippocampus frog	Ringer solution	2 4
21	Hypothalamus rat	Ringer glucose	10 4
22	Medulla cat	Ringer glucose	5 5
23	Medulla, rat 5 da	Ringer glucose	3 4
24	Medulla, rat, 50 da	Ringer glucose	9 0
25	Medulla rat adult	Ringer glucose	2 5-4 9
26	Nerve, sciatic frog	Ringer solution	0 3
27	Nerve trigeminal sheep	Ringer solution	0 5
28	Retina dog	Ringer glucose	20 8
29	Retina, frog	Ringer glucose	5 5
30	Retina ox	Ringer glucose	10 7
31	Retina pig	Ringer glucose	17 7
32	Retina, rat	Ringer glucose	22 0-32
33	Spinal cord cat	Ringer glucose	1 3
34	Spinal cord, frog	Ringer glucose	2 3

133 OXYGEN CONSUMPTION; NERVE TISSUE: DOG

Values are the cu mm oxygen consumed per mg minced fresh tissue per hour[1] Minced fresh tissue is immersed in a phosphate saline medium containing glucose Rate varies with the medium (cf Fn 2) In general, values rise from age 1 week to a peak at 5-7 weeks The faster rates are found in the lower portions of the neuraxis at 1 week, and in the upper parts in the adult

	Tissue / Age	1st Week	3rd Week	5-7th Week	Adult
	(A)	(B)	(C)	(D)	(E)
1	Cerebral cortex	0 61	0 68	1 21	1 16[2]
2	Caudate nucleus	0 73	0 96	1.39	1 36
3	Thalamus	0 76	0 97	1.24	1.01
4	Midbrain	0 91	1 11	1.28	0 92
5	Cerebellum	0 79	0 87	0 95	1.07
6	Medulla oblongata	0 96	1 03	0 85	0 69
7	Spinal cord	0 81	0 93		0 50

/1/ Since fresh nerve tissue contains approximately 75% water, values can be converted to a per mg dry weight basis by multiplying by 4 /2/ Adult dog cerebral cortex slices, average 2.3 in Ca free Ringer phosphate; 1 4 in complete Ringer-bicarbonate; and 4 24 in a Ca-free phosphate saline medium supplemented with pyruvate fumarate and glutamate

134 ANAEROBIC GLYCOLYSIS NERVE TISSUE: CAT DOG

Values are the cu mm carbon dioxide liberated per mg moist weight of minced fresh tissue per hour in the absence of oxygen. Minced fresh tissue is immersed in a bicarbonate medium with added glucose CO_2 values represent displacement of CO_2 from bicarbonate by metabolically formed acid. 1 cu mm of carbon dioxide corresponds to 4 µg lactic acid. Individual determinations vary as much as 100%

	Tissue / Age	Cat[1]			Dog[1]			
		Less than 1 Week	5-7 Weeks	Adult	Less than 1 Week	3-6 Weeks	3 Months	Adult
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1	Cerebral cortex	0 43	1 88	1.78[2]	0.46	1.17	1 95	2 85
2	Caudate nucleus	0 85	2.21	2 59	0 73	1 57	2 56	2.29
3	Thalamus	0 83	2 09	1 67	1.04	1.60	2 43	1.93
4	Corpora quadrigemina	1.05	1 61	0 60	1.16	1 48	1.57	0.85
5	Cerebellum	0 95	1 09	0 60	0 94	0 73	1.24	0 75
6	Medulla oblongata	1 57	1.05	0 54	1 44	1.18	0 61	0 50
7	Spinal cord	0.76	0.27	0 17	0 87	0 58	0 18	0 80

/1/ At one week the highest rate of glycolysis is found in the medulla while in the adult it occurs in the caudate nucleus and cerebral cortex. In general a slight recession from the maximum glycolysis is observed in the adult /2/ It has been verified that the displacement of CO_2 in measurements on the adult cat cerebral cortex is due to the production of lactic acid. It is assumed that other parts of the cat brain also produce exclusively lactic acid under these conditions.

135 OXYGEN CONSUMPTION REPRODUCTIVE TISSUES INCLUDING GONADS AND SPERM

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient $-Q_{O_2}$) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure and maintained at ±37° C The decrease in amount of gaseous O_2 as it is used by the tissue is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue glucose or other nutrient may be added to the medium.

Animal and Tissue (A)	Medium (B)	$-Q_{O_2}$ (C)
1 Mammary gland, rat termination of pregnancy	Ringer glucose	1 3
2 15-22 da lactation	Ringer glucose	10 0
2 da after weaning	Ringer glucose	5 5
4 Ovary mouse	Serum	9 0
Ovary rat	Ringer glucose	5 7
Prostate rat	Ringer glucose	7 6
Seminal vesicles guinea pig, Epithelium	Ringer glucose	6 1
Epithelium of castrate	Ringer glucose	2 8
Smooth muscle	Ringer glucose	1 7
Smooth muscle of castrate	Ringer glucose	1.4
1 Sperm, human	Ringer phosphate	0 5
1 Sperm, bull	Ringer phosphate	6 6
3 Sperm, bull	Horse serum	11 2
4 Sperm, bull	Horse serum glucose	12 8
Sperm, bull epididymal	Ringer phosphate	2 6
1 Sperm, fowl ejaculated	Ringer phosphate	2 8
1 Sperm, guinea pig	Ringer phosphate	8 0
1 Sperm, guinea pig	Serum	18 4
1 Sperm, rabbit ejaculated	Ringer phosphate	4.4
Sperm, ram, ejaculated	Ringer phosphate	9 0
1 Sperm, rat	Serum	
Testis rabbit	Ringer glucose	7 7
Testis rat	Ringer glucose	7 5-14 3
4 Testis rat	Serum	11 0
Uterus rat	Ringer glucose	7 6
Uterus rat	Ringer solution	3 7
Uterus rat castrate	Ringer solution	5 2
Uterus rat castrate plus		

136 OXYGEN CONSUMPTION REPRODUCTIVE TISSUES PLACENTA MEMBRANES AND EMBRYO

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$) Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at <1 atmosphere pressure, and maintained at ±37° C The decrease in amount of gaseous O_2, as it is used by the tissue, is measured The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added t the medium

Animal and Tissue (A)	Medium (B)	$-Q_{O_2}$ (C)
1 Allantois, chick	Ringer glucose	22 3
2 Chorion, rat	Ringer glucose	13 5
Decidua, human	Serum	2 5
4 Embryo, chick, 0.1-1 2 g	Serum	15 9-21 4
Embryo, chick, 4 7 g	Serum	8 1
6 Embryo, chick, 5-6 da	Ringer solution	10 0-12 0
Embryo, chick, 12 da	Ringer solution	9 9
8 Embryo, chick, 19 da	Ringer solution	7 7
Embryo, mouse	Ringer glucose	10 4
10 Embryo, rabbit	Ringer glucose	8 5
11 Embryo, rat, 1-3 mg	Serum	10 5-14 6
1 Embryo, rat, 13-14 da	Ringer glucose	7 2-11 0
1 Placenta, mouse, 0 4 mg	Serum	7 5
14 Placenta, mouse, 10 9-13 7 mg	Serum	6 4
1 Placenta, rabbit, fetal side	Serum	5 3
16 Placenta, rabbit, uterine side	Serum	3 4
17 Placenta, rat, 20 da	Ringer solution	7 3

137 CORRELATION OF O_2 CONSUMPTION WITH BODY SIZE INVERTEBRATES

A general form of the relation of oxygen consumption to body size: $M = bW^{\alpha}$ (M = O_2 consumption, W = body weight, b and α = constants). All values in columns B and D except 1B and 1D are read from smoothed log log plots of O_2 consumption against body weight according to $\log M = \log b + \alpha \log W$ or against body length, if so indicated. Plotting the indicated values on double-logarithmic paper and connecting them with a straight line approximate values for intermediate sizes may be obtained.

	Species	Body Weight (mg or g) or Length (mm)	Temperature °C	O_2 Consumption cu mm/hr	Respiratory Quotient[1]
	(A)	(B)	(C)	(D)	(E)
	Protozoa				
1	Amoeba (Chaos chaos)	0 05 mg	22.5	0 008-0 015	0 82
	Platyhelminthes				
2	Planaria (Dugesia gonocephala)	4-65 mg	20	1.1-9.8[2]	0 71
	Nemathelminthes				
3	Ascaris (Ascaris lumbricoides)	320-7760 mg	37	84-480[3]	
	Annelida				
4	Earthworm (Lumbricus spp)	200-2500 mg	20	16 3-212[4]	
5	Manure worm (Eisenia foetida)	12-850 mg	15	2 6-37[3]	
	Mollusca				
6	Mussel freshwater (Anodonta cygnea)				
7	Snail Viennese garden (Cepaea vindobonensis)	120-2650 mg[5]	20	5 1 102[4,6]	1
8	Snail land (Helix Helicigona, Cepaea)				
9	Snail pond ear (Radix auricularia)	12.5-52.8 mm	25	39-600[4,7]	0 90
10	Snail pond great (Lymnaea stagnalis)	1550-5500 mg	15	60-100[2]	
11	Snail pond great (L. stagnalis)	140-1700 mg	20	11-66[2]	
12	Snail ramshorn (Planorbarius corneus)	1730-5770 mg	15	34-182[2]	
13	Snail ramshorn (P corneus)	5.8-32 mm	25	2.4-225[2,7]	0 88
14	Snail ramshorn (Planorbis spp)	35-500 mg	25	2.7-20 9[2]	1.00
15	Snail river (Viviparus viviparus)	8 5-34 mm	25	8 5-120[3]	
16	Snail river (V fasciatus)	3.5-37 mm	25	2 5-245[3,7]	0 60
	Arthropoda, Crustacea				
17	Bug pill (Armadillidium pallasi)	15-160 mg	21	3.2 16.2[3]	0 94
18	Bug, sow (Oniscus asellus)	6-16 mm	25	3-22[3]	0 95
19	Bug sow (Porcellio scaber)	6-20 mm	25	4-70[2]	1.01
20	Crab kelp (Pugettia producta)	72.35-329 g[8]	15	0 45-14 5 ml[2,9]	
21	Crayfish (Astacus astacus)				
22	Crayfish (Potamobius torrentium)				
23	Flea water (Daphnia pulex)	0.71 1 10 mm	21	0 0196-0 073[3]	
24	Isopod, freshwater (Asellus aquaticus)	4 5-11.5 mm	20	1.6-10 1[3]	
25	Isopod freshwater (A. aquaticus)	3-12 mm	25	1.84-11.9[3]	0.88
26	Shrimp brine (Artemia salina)	0 35-10 mm	30	0 015-11.3[3]	
	Arthropoda, Insecta				
27	Cockroach, oriental (Blatta orientalis)	6.5-32 mm	25	6 5-600[4]	1.06
28	Mealworm yellow (Tenebrio molitor)	20-220 mg	20	10.2 101[4]	0 70
29	Walking stick, oriental (Dixippus morosus)	8-850 mg	20	2 6-206[4]	0 86

/1/ CO_2 liberated ÷ O_2 consumption. /2/ O_2 consumption varies as a power of body weight intermediate between 0 67 and 1 0 (cf Pa 3 4) /3/ O_2 consumption varies as the two-thirds power of body weight ($M \propto W^{0.67}$) /4/ O_2 consumption varies with body weight ($M \propto W^{1.0}$) /5/ Winter Spring, 200-2730 mg /6/ Winter Spring 24-281 cu mm/hr /7/ Values corrected by Krywienczyk, J /8/ 71.6-119 g /9/ Note change in units ml/hr 20.17 12 7 ml/hr

138 OXYGEN CONSUMPTION ENDOPARASITIC HELMINTHS

	Species	Specification	Temperature °C	Cu mm O_2/mg dry substance/hr[1]	Cu mm O_2/mg dry substance/hr[2]
	(A)	(B)	(C)	(D)	(E)
1	Paramphistomum cervi	Adults	38	0.03	
2	Schistosoma mansoni	Pairs	37 5	6 0	8 7
3	S mansoni	Males	37 5		9.1
4	S mansoni	Females	37 5		10 7
5	Fasciola hepatica	Adults	37 5	1 94	
6	Diphyllobothrium latum	Proglottids	37	2 7	15.0
7	D latum	Plerocercoids	22	0 34	0 67
8	Moniezia expansa	Head region	37 5		1 1
9	M expansa	Mature progl	37 5		0 9
10	M. expansa	Gravid progl	37 5		0 6
11	Trichinella spiralis	Larvae	37 5	2 35	2 37
12	Strongylus equinus	Adults	38	3 3	
13	S vulgaris	Adults	38	3 6	
14	Haemonchus contortus	Eggs (morula)	30	9 7	
15	H contortus	Eggs (blastula)	30	10 7	
16	H contortus	Larvae	30	12 6	
17	Ostertagia circumcincta	Adults	38	7 4	
18	Nematodirus spp	Adults	37	5.1	
19	Nippostrongylus muris	Larvae (1 day)	30	18 4	
20	N muris	Larvae (4 days)	30	13.0	
21	N muris	Larvae (12 days)	30	9.2	
22	N muris	Adults	37	6 8	
23	Eustrongylides ignotus	Larvae	37	0 56[3]	
24	Syphacia obvelata	Adults	38	4 4	
25	Neoaplectana glaseri	Adults	30	12 6	
26	Heterakis spumosa	Adults	38	4 0	
27	Ascaris lumbricoides	Small	39	0 42[3]	
28	A. lumbricoides	Males	37	0 59[3]	
29	A. lumbricoides	Females	37	0 32[3]	
30	A. lumbricoides	Small	37	0 82[3]	
31	A. lumbricoides	Large	37	0 33[3]	
32	Ascaridia galli	Adults	37	2 5	

/1/ No glucose /2/ In presence of glucose /3/ Figures calculated from data on dry matter percentage

139 OXYGEN CONSUMPTION PARASITIC PROTOZOA

Data are applicable to parasitic protozoa in presence of glucose

	Organism	Specification	Temperature C	Cu mm O_2 per 100 million[1] per hour
	(A)	(B)	(C)	(D)
1	Strigomonas oncopelti	Culture	28	41[2]
2	S fasciculata	Culture	28	37[2]
3	Leptomonas ctenocephali	Culture	28	27[2]
4	Leishmania tropica	Culture	32;37;28	31;45,39
5	L brasiliensis	Culture	28;32;37	42;32;65
6	L donovani	Culture	37;28;32;25	38;18;27;44
7	Trypanosoma lewisi	Bloodstream, old	37	69
8	T lewisi	Bloodstream, young	37	50
9	T cruzi	Bloodstream	28;37	44;109 124
10	T cruzi	Culture	28;32;37	25;43;33
11	T conorhini	Culture	28	26
12	T pipistrelli	Culture	30	13
13	T congolense	Bloodstream	37	153
14	T evansi	Bloodstream	37	166
15	T hippicum	Bloodstream	37;38	66;200
16	T equinum	Bloodstream	37	166
17	T equiperdum	Bloodstream	28;37	53;91,185
18	T rhodesiense	Bloodstream	28;37	77;103,194
19	T gambiense	Bloodstream	37	170
20	T gambiense	Culture	28;30 37	14 38;21
21	Trichomonas foetus	Culture	28	215
22	T hepatica	Culture	38	600
23	Plasmodium knowlesi	Rings	38	8
24	P knowlesi	3/4-grown segmenters	38	34
25	P inui	Rings, amoeb	38	9
26	P cynomolgi	Segmenters		47
27	P cathemerium	1/4-grown	38	10
28	P cathemerium	3/4-grown	38	25
29	P lophurae	1/2-3/4-grown	38	18

/1/ Estimated number of organisms /2/ Calculated from dry weight data.

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2 Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram fresh weight of plant part per hour Unless otherwise specified, data are applicable to the mature leaf

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
1	Barley (Hordeum vulgare)	22 5	637	628[2]	1 0
2	Bouncing bet (Saponaria officinalis)	21	418	510	0 8
3	Broadbean (Vicia faba)	21		700	
4	Carrot (Daucus carota)	22		439[3]	
5	Corn (Zea mays)[4]	25		320	
6	Curly dock (Rumex crispus)[5]	20	152-202		
7	Ivy, English (Hedera helix)	25[6]		400-780	
8	Kalanchoe (Bryophyllum sp)	20		404	
9	Laurel cherry (Prunus laurocerasus)	22 5	158		
10	Lettuce (Lactuca sativa)	24	25[7]		
11	Potato (Solanum tuberosum)	20	277[8]		
12	Privet (Ligustrum lucidum)	25		500 1,200	
13	Rhododendron (Rhododendron sp)	20	25[9]		
14	Sedum (Sedum dendroideum)[10]	18	12	29	0 4
15	Snapdragon (Antirrhinum majus)	24		175	
16	Spatterdock (Nuphar advenum)	25	168		
17	Spinach (Spinacia oleracea)	30	630	625	1 0
18	Tobacco (Nicotiana tabacum)	26		400	
19	Tomato (Lycopersicon esculentum)	25	91		
20	Viburnum (Viburnum sp)	20	109		
21	Wandering Jew (Zebrina pendula)	25	38		
22	Wheat (Triticum vulgare)	22		935-1 078	
23	Yucca (Yucca gloriosa)	22 5	78		

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Young leaf at 25° C 165-295 /3/ Young leaf, 1,133 /4/ Data applicable to young leaf /5/ Recorded values represent data from two different tests; therefore a respiratory quotient is not calculated /6/ At 20° C, 125 cu mm CO_2 released /7/ At 0° C, 1 5; at 4 5° C, 17 2; at 15 5° C, 51 /8/ At 25° C, 318; at 26° C 333 at 29° C, 374 /9/ Value applicable to winter leaves For young summer leaves 56 /10/ Data applicable to leafy stem.

141 RATES OF RESPIRATION ROOTS RHIZOMES TUBERS, BULBS

Respiration in plant tissue as in animal tissue involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram fresh weight of plant part per hour

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Roots				
1	Beet garden (Beta vulgaris)[2]	15 5	7.5-8.1[3]		
2	Carrot (Daucus carota)	20	44[4]	42[5]	1.1
3	Corn (Zea mays)	25		486[6]	0 8-0 9
4	Pea garden (Pisum sativum)	20		40	
5	Radish (Raphanus sativus)[2]	20	78		
6	Rutabaga (Brassica napobrassica)	22	31		
7	Sweetpotato (Ipomoea batatas)	26 5	15.2-20.2[7]		
8	Turnip (Brassica rapa)	15 5	15 7[8]		
9	Wheat (Triticum vulgare)	22		1 338[9]	
	Rhizomes				
10	Milkweed swamp (Asclepias incarnata)	25	34		
11	Spatterdock (Nuphar advenum)	25	26		
12	Sweetflag (Acorus calamus)	25	34		
	Tubers				
13	Potato (Solanum tuberosum)	20.2	6 6[10 11]	11 9	0 5
	Bulbs				
14	Onion (Allium cepa)	21	7.1-9 6[12 13]		
15	Tulip (Tulipa sp)	25		20	

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Data applicable to root slices /3/ At 0° C, 2 5; at 4 5° C 4 3 /4/ At 0° C 2; at 4 5° C, 5 3; at 15 5° C 8 6 /5/ At 25° C 36-43 /6/ Value applicable to primary root tip, 3 days after germination. For adventitious root portions (root tips not included), 2 weeks after germination, 82. /7/ At 4 5° C 2 3 /8/ At 0° C 0 2; at 4 5° C 1 5 /9/ Value applicable to root tip For rootlet in growth zone 1 200; for rootlet in root hair zone 501-625 /10/ At 15° C, 2 3 /11/ Immature tuber at 20° C 16 8 /12/ At 0° C, 2 0; at 10° C 4 /13/ At 25° C 9 cu mm O_2 absorbed

142 RATES OF RESPIRATION SEEDS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2 Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram fresh weight of seeds per hour Unless otherwise specified, data are applicable to seeds with imbibed water

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
1	Apricot (Prunus armeniaca)	20		70	
2	Barley (Hordeum distichum)	29	74[2]	73	1 0
3	Broadbean (Vicia faba)[3]	21	456		
4	Cherry, sour (Prunus cerasus)	20		63	
5	Hawthorn (Crataegus sp)	20		42	
6	Juniper, common (Juniperus communis)	25		91[4]	
7	Oat (Avena sativa)[5]	20	0 001		
8	Pea, garden (Pisum sativum)[5]	24	141[6]		
9	Peach (Prunus persica)	20		56	
10	Plum (P domestica)	20		49	
11	Pumpkin (Cucurbita pepo)[3]		423		
12	Rye (Secale spp)[5]	20	0 001		
13	Sorghum (Sorghum vulgare)	20	0 002[7]		
14	Wheat (Triticum vulgare)[5]	20[8]	0 002[9]		

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Air dry seeds at 20° C, 0 001 /3/ Data applicable to germinating seeds /4/ Air dry seeds at 25° C, 0 7 /5/ Data applicable to air dry seeds /6/ Air dry seeds at 15° C 0; freshly harvested at 15° C, 101 /7/ Air dry seeds 0 0001 /8/ Germinating seeds at 16 5° C 108 cu mm O_2 absorbed /9/ Germinating seeds at 16 5° C, 58

141 RATES OF RESPIRATION ROOTS RHIZOMES, TUBERS BULBS

Respiration in plant tissue as in animal tissue involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram fresh weight of plant part per hour

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Roots				
1	Beet garden (Beta vulgaris)[2]	15 5	7 5-8 1[3]		
2	Carrot (Daucus carota)	20	44[4]	42[5]	1.1
3	Corn (Zea mays)	25		486[6]	0 8-0 9
4	Pea garden (Pisum sativum)	20		40	
5	Radish (Raphanus sativus)[2]	20	78		
6	Rutabaga (Brassica napobrassica)	22	31		
7	Sweetpotato (Ipomoea batatas)	26 5	15 2-20.2[7]		
8	Turnip (Brassica rapa)	15 5	15 7[8]		
9	Wheat (Triticum vulgare)	22		1 338[9]	
	Rhizomes				
10	Milkweed swamp (Asclepias incarnata)	25	34		
11	Spatterdock (Nuphar advenum)	25	26		
12	Sweetflag (Acorus calamus)	25	34		
	Tubers				
13	Potato (Solanum tuberosum)	20.2	6 6[10 11]	11 9	0 5
	Bulbs				
14	Onion (Allium cepa)	21	7 1-9 6[12 13]		
15	Tulip (Tulipa sp)	25		20	

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Data applicable to root slices /3/ At 0° C 2 5; at 4 5° C 4 3 /4/ At 0° C 2; at 4 5° C, 3 3; at 15 5° C 8 6 /5/ At 25° C 36-43 /6/ Value applicable to primary root tip 3 days after germination. For adventitious root portions (root tips not included), 2 weeks after germination 82 /7/ At 4 5° C, 2 3 /8/ At 0° C 0 2; at 4 5° C 1 3 /9/ Value applicable to root tip For rootlet in growth zone 1 200; for rootlet in root hair zone 301-625 /10/ At 15° C, 2 3 /11/ Immature tuber at 20° C 16 8 /12/ At 0° C, 2.0; at 10° C, 4 /13/ At 25° C 9 cu mm O_2 absorbed

142 RATES OF RESPIRATION SEEDS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2 Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram fresh weight of seeds per hour Unless otherwise specified, data are applicable to seeds with imbibed water

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
1	Apricot (Prunus armeniaca)	20		70	
2	Barley (Hordeum distichum)	29	74[2]	73	1 0
3	Broadbean (Vicia faba)[3]	21	456		
4	Cherry, sour (Prunus cerasus)	20		63	
5	Hawthorn (Crataegus sp)	20		42	
6	Juniper, common (Juniperus communis)	25		91[4]	
7	Oat (Avena sativa)[5]	20	0,001		
8	Pea, garden (Pisum sativum)[5]	24	141[6]		
9	Peach (Prunus persica)	20		56	
10	Plum (P domestica)	20		49	
11	Pumpkin (Cucurbita pepo)[3]		423		
12	Rye (Secale spp)[5]	20	0 001		
13	Sorghum (Sorghum vulgare)	20	0 002[7]		
14	Wheat (Triticum vulgare)[5]	20[8]	0 002[9]		

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Air dry seeds at 20° C, 0 001./3/ Data applicable to germinating seeds /4/ Air dry seeds at 25° C 0 7 /5/ Data applicable to air dry seeds /6/ Air dry seeds at 15° C 0; freshly harvested at 15° C, 101 /7/ Air dry seeds, 0 0001 /8/ Germinating seeds at 16 5° C, 108 cu mm O_2 absorbed /9/ Germinating seeds at 16 5° C 58

143 RATES OF RESPIRATION FRUITS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2 Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram fresh weight of the fruit per hour Unless otherwise specified, data are applicable to the mature fruit

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
1	Apple (Pyrus malus)	27	9[2]	10[2]	0 9
2	Avocado (Persea gratissima)	15	35-90	40-105	0 9
3	Banana (Musa paridisima sapientum)[3]	20		55[4]	
4	Cucumber (Cucumis sativus)	24	21		1 0
5	Lemon (Citrus limonia)[5]	15	4 1-4 6	5 7-6 6	0 7
6	Orange, sweet (C sinensis)	21		12 5	
7	Papaya (Carica papaya)	25	41[6]		
8	Peach (Prunus persica)	21		27	
9	Pear (Pyrus communis)	20	13		
10	Pepper (Capsicum frutescens)	24	38		1 1
11	Strawberry (Fragaria vesca)	20	59[7]	180	0 2
12	Tomato (Lycospericon esculentum)	15-17	9 9[8]	11 5[8]	0 9

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Immature fruit CO_2, 35; O_2, 50 /3/ Data applicable to yellow fruit /4/ For overripe fruit, 59; immature, 77 For CO_2 released overripe fruit, 60, immature, 76 /5/ Data applicable to immature fruit /6/ Immature fruit, 18 8; yellow, 28 /7/ Immature fruit, 22 /8/ Immature fruit CO_2, 12-87; O_2, 20-92

144 RATES OF RESPIRATION MOSSES FERNS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas (at S T P) per gram dry weight (unless otherwise specified) of plant material per hour

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Mosses and Moss Allies (Bryophyta)				
1	Chiloscyphus fragilis	25		600 1 000	
2	Fontinalis antipyretica	25		700 1 400	
3	Hypnum cupressiforme			140[2]	
4	Riccia fluitans	25		2,500-30 000	
5	Sphagnum cuspidatum[3]		1 20	1 270	1 0
6	S cuspidatum[4]		,290	2,430	0 9
	Ferns and Fern Allies (Pteridophyta)[5]				
7	Club-moss small (Selaginella martensii)	25	500		
8	Fern bracken (Eupteris aquilina)	20	6 100		
9	Fern, Hart s tongue (Phyllitis scolopendrium)[6]	16		257[7]	
10	Fern Hart s tongue (P scolopendrium)[8]	16		[illegible][7]	
11	Fern, polypody (Polypodium vulgare)[9]	19 5	175[7]	164[7]	1 1
12	Fern polypody (P vulgare)[10]	19 5	96[7]	105[7]	0 9
13	Fern, shield (Dryopteris austriaca)	20	800[7]		
14	Horsetail (Equisetum telmateia)[11]	20	52[7]	67[7]	0 8
15	Horsetail (E telmateia)[12]	20	93[7]	112[7]	0 3

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Value applicable to air dry conditions /3/ Data applicable to dry habitat /4/ Data applicable to wet habitat /5/ Data applicable to leaves unless otherwise specified /6/ Data applicable to mature leaf /7/ Value calculated on wet ...

145 RATES OF RESPIRATION FUNGI, LICHENS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2 Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram dry weight (unless otherwise specified) of plant material per hour

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Fungi				
1	Agaricus campestris[2]	14	71[3 4]	129[3]	0 6
2	Aspergillus clavatus	23,25[5]	5,610	3,230	1 7
3	A. niger	25[5]		15,000-20 000	
4	Blastomyces dermatitidis[6]	20		2,400	
5	B dermatitidis[7]	20		14,150	
6	Daedalea quercina	40		9,400[3]	
7	Fusarium sp	30[8]		40,000	
8	Myrothecium verrucaria[9]	30		58,000	
9	M verrucaria[10]	30		108,000	
10	Neurospora tetrasperma[11]	25	9,620-19,600	9,620-19,600	1 0
11	N tetrasperma[12]	25		250-590	
12	Penicillium notatum	19,8-24 2[13]		15,000	
13	Phycomyces blakesleeanus	20[5]	25,000-30,000		
14	Physarum polycephalum[14]	22		400	0 8
15	P polycephalum[15]	22		1,400	
16	Pilobolus kleinii	26[6]		2,600	
17	Polyporus versicolor	25	3,300[3]		
18	Saccharomyces sp	28[5]		40,000-80,000	
19	Thelephora tremelloides	9		940[3]	
20	Zygosaccharomyces sp	28[5]		60 000	
	Lichens				
21	Cladonia rangiferina	10	116	145	0 8
22	Peltigera canina	21	70-140[3]		

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Also known as Psalliota campestris /3/ Calculated on wet weight basis /4/ At 25°C, 4,800; cf Fn 3 /5/ Glucose in media. /6/ Data applicable to young mycelium form /7/ Data applicable to yeast form. /8/ Endogenous /9/ Data applicable to a 48-hour culture /10/ Data applicable to a 28-hour culture /11/ Data applicable to anaerobic respiration of germinating ascospores /12/ Data applicable to anaerobic respiration of dormant ascospores /13/ Lactose in media. /14/ Data applicable to large mass plasmodium (protoplasmic mass) /15/ Data applicable to small mass plasmodium.

146 RATES OF RESPIRATION ALGAE

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2 Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time Gas volumes are expressed in cu mm of gas (at S T P) per gram dry weight of plant material per hour

	Species	Temperature °C	Carbon Dioxide Released cu mm/g/hr	Oxygen Absorbed cu mm/g/hr	Respiratory Quotient[1]
	(A)	(B)	(C)	(D)	(E)
	Cyanophyta (Blue-green)				
1	Anabaena sp	25		4 500	
	Chlorophyta (Green)				
2	Chlorella ellipsoidea	25		1 300	
3	C pyrenoidosa	25[2 3]	1,600-12 800	1,400-11,200	1 1
4	Cladophora arcta	12		900	
5	Enteromorpha linza	25		1 100	
6	Nitella clavata[4]	23		20,000-30 000	
7	Scenedesmus obliquus	25[2]		500	
8	Spirogyra sp [5]	35	260-610	1,260-2 100	0 2-0 3
9	Spirogyra sp [6]	35	1 530-2 190	1,400-2,100	1 0
10	Ulva lactuca	18 1	472	493	0 9
11	U lactuca	25		2,600	
	Phaeophyta (Brown)				
12	Ascophyllum nodosum			2 940	
13	Fucus serratus	18 3	165	307	0 5
14	Laminaria phyllitis			900	
	Rhodophyta (Red)				
15	Chondrus crispus	14		400	
16	Gigartina teedii	11 6		440	
17	Polysiphonia violacea	11 1	1 031	891	1.2

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed /2/ Endogenous /3/ In glucose solution CO_2, 23,000; O_2, 19 000 /4/ Data applicable to plant tips /5/ Data applicable to sexual (conjugating) stage /6/ Data applicable to vegetative stage

147 OXYGEN CONSUMPTION BACTERIAL SUSPENSIONS

Data are applicable to bacterial supensions in the presence of glucose, unless otherwise specified The oxidation quotient, $-Q_{O_2}$, is the cu mm of O_2 consumed per mg dry weight per hour

	Organism	Age of cell hr	Temp °C	$-Q_{O_2}$
	(A)	(B)	(C)	(D)
1	Azotobacter chroococcum	36	22	2000-10,000
2	Aerobacter aerogenes	17 48	36;30	47,50
3	Bacillus cereus (short)	18	30?	42-86
4	B Cereus (filamentous)	18	30?	3-49
5	B Subtilis	6-8	37	170
6	B Subtilis, spores	98-147	32	10
7	Corynebacterium sp	48-96	30?	67
8	Escherichia coli	20	40;32	200;272
9	Lactobacillus bulgaricus	8	37;45	34;55
10	Leuconostoc citrovorum	16	38	8
11	Micrococcus luteus	30-34	35	15
12	M flavus	30-34	35	8
13	M auranticus	30-34	35	14
14	M cinnebareus	30-34	35	32
15	M Fruendenreichii	30-34	35	20
16	Mycobacterium phlei	84	38	28
17	M smegmatis	84	38	23
18	M stercoris	84	38	15
19	M sp Karlinski	84	38	22
20	M ranae	84	38	32
21	M leprous kedrowsky	84	38	8
22	M butyricum	84	38	13
23	M tuberculosis hominis	252	38	4
24	M tuberculosis avian	84	37	1
25	Pneumococcus, Type I	18	37	27
26	Pseudomonas fluorescens	20	26	58
27	Streptococcus faecalis, B33A	18	38	106
28	S Faecalis, 10C1	15	37	57-80
29	S Faecalis, Lancefield D	12-15	37	7
30	S pyogenes, C203M	4	37 5	57-163[1,2]
31	S pyogenes, C203S	4	37 5	99-113[1,3]
32	S thermophilus, C3	8	37 50	4;5
33	S thermophilus, MC	8	37;50	9;10
34	Streptomyces coelicolor	72		35

/1/ In a medium containing yeast extract /2/ In a medium composed of saline and glucose, 17-24 /3/ In a medium composed of saline and glucose, 25-42

148 BASAL METABOLISM MAN

Values (col B D) are smoothed means of basal Calories per sq m per hr from the three largest and most authoritative sets of original data representing a total of 4016 measurements The three sets of data used are: (1) The Mayo Foundation Standards of Boothby Berkson and Dunn based upon 639 males and 828 females;(2) The British measurements of Robertson and Reid, based upon 987 males and 1323 females; (3) The Carnegie Nutrition Laboratory Data of Harris and Benedict based upon 136 males and 103 females. The height-weight formula of DuBois and DuBois was used in computing the sq m of body surface area: SA = $0\ 007184 \times W^{0\ 425} \times H^{0\ 725}$ where SA is the surface area in square meters, W is the body weight in kilograms and H is the height in centimeters Ranges are calculated from an average coefficient of variation[1] of 6 9% and represent estimate "b of the 95% range Somewhat higher values are to be expected on first tests (i e on persons not accustomed to the procedures) For comparison of these standards with previous American and other important standards see table 149

Line No.	Age yr	Males Value	Males Range	Females Value	Females Range
		Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr
	(A)	(B)	(C)	(D)	(E)
1	Three	60 1	51 8-68 3	54 5	47 0-62 0
2	Four	57 9	49 9-65 9	53 9	46 5-61 3
3	Five	56 3	48 5-64 1	53 0	45 7-60 3
4	Six	54 0	46 5-61 5	51.2	44 1 58 3
5	Seven	52 3	45 1 59 5	49 7	42 8-56 6
6	Eight	50 8	43 8-57 8	48 0	41 4-54 6
7	Nine	49 5	42 7 56 3	46 2	39 8-52 6
8	Ten	47 7	41 1 54 3	44 9	38 7 51 1
9	Eleven	46 5	40 1 52 9	44 1	38 0-50 2
10	Twelve	45 3	39 0-51 6	42 0	36.2-47 8
11	Thirteen	44 5	38 4-50 6	40 5	34 9-46 1
12	Fourteen	43 8	37 8-49 8	39 2	33 8-44 6
13	Fifteen	43 7	37 7-49 7	38 3	33 0-43 6
14	Sixteen	42 9	37 0-48 8	37 7	32 5-42 9
15	Seventeen	41 9	36 1-47 7	36 2	31 2-41 2
16	Eighteen	40 5	34 9-46.1	35 7	30 8-40 6
17	Nineteen	40 1	34 6-45 6	35 4	30 5-40 5
18	Twenty	39 8	34 5-45 3	35 3	30 4-40 2
19	Twenty-one	39 4	34 0-44 8	35 2	30 3-40 1
20	Twenty two	39 2	33 8-44 6	35 2	30 3-40 1
21	Twenty three	39 0	33 6-44 4	35 2	30 3-40 1
22	Twenty four	38 7	33 4-44 0	35 1	30 3-39 9
23	Twenty five	38 4	33 1-43 7	35 1	30 3-39 9

Line No.	Age yr	Males Value	Males Range	Females Value	Females Range
		Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr
	(A)	(B)	(C)	(D)	(E)
24	Twenty-six	38 2	32 9-43 5	35 0	30 2 39 8
25	Twenty-seven	38 0	32 8-43 2	35 0	30 2-39 8
26	Twenty eight	37 8	32 6-43 0	35 0	30 2-39 8
27	Twenty nine	37 7	32 5-42 9	35 0	30 2-39 8
28	Thirty	37 6	32 4-42 8	35 0	30 2 39 8
29	Thirty one	37 4	32 2-42 6	35 0	30 2 39 8
30	Thirty two	37 2	32 1-42 3	34 9	30 1-39 7
31	Thirty-three	37 1	32 0-42 2	34 9	30 1-39 7
32	Thirty-four	37 0	31 9-42.1	34 9	30 1 39 7
33	Thirty five	36 9	31 8-42 0	34 8	30 0-39 6
34	Thirty six	36 8	31 7-41 9	34 7	29 9-39 5
35	Thirty-seven	36 7	31 6-41 8	34 6	29 8-39 4
36	Thirty-eight	36 7	31 6-41 8	34 5	29 7 39 3
37	Thirty nine	36 6	31 5-41 7	34 4	29 7 39 1
38	Forty	36 5	31 5-41 5	34 3	29 6-39 0
39	Forty-five	36 3	31 5-41 3	33 9	29 2 38 6
40	Fifty	36 0	31 0-40 0	33 4	28 8-38 0
41	Fifty-five	35 4	30 5-40 3	32 9	28 4-37 4
42	Sixty	34 8	30 0-39 6	32 4	27 9-36 9
43	Sixty five	34 0	29 3-38 7	31 8	27 4-36 2
44	Seventy	33 1	28 5-37 7	31 3[3]	27 0-35 6
45	Seventy-five[2]	31 8	27 4-36 2	31 1[3]	26 8-35 4

/1/ Coefficient of variation = 6 9 = average of values from five sources (cf bibliography) /2/ Data applicable to ages seventy five and above /3/ Value (and range) extrapolated from smoothed curve

Column F is the standard commonly employed heretofore in America The underlying measurements include many first tests (on persons unaccustomed to the procedures) Values are accordingly high — the highest of the standards Values in column D, the British Standard, are based on the lowest of repeated measurements on trained persons under rigorously basal conditions Measures taken to eliminate metabolism-raising influences have been particularly effective with adults, yielding lower values than those in any other column. Values in column E are based on measurements on well trained children and are generally the low-

Line No	Age yr	Males				
		Boothby[1] 1952	Fleisch[2] 1951	Robertson and Reid[3] 1952	Lewis Duval and Iliff[4] 1943	Boothby Berkson and Dunn[5] 1936
		Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr
	(A)	(B)	(C)	(D)	(E)	(F)
1	One		53 0			
2	Two		52 4		56 9	
3	Three	60 1	51 3	60 1	54 5	
4	Four	57 9	50 3	57 9	52 6	
5	Five	56 3	49 3	56 3	51 0	
6	Six	54 0	48 3	54 2	49 6	53 0
7	Seven	52 3	47 3	52.1	48 2	52 4
8	Eight	50.8	46 3	50 1	46 6	51 5
9	Nine	49 5	45 2	48.2	45 0	49 9
10	Ten	47 7	44 0	46 6	43 6	48 0
11	Eleven	46 5	43 0	45 1	42 2	47.2
12	Twelve	45 3	42 5	43 8	41 5	46 8
13	Thirteen	44 5	42 3	42 7	41 4	46 5
14	Fourteen	43 8	42 1	41 8	41 1	46 4
15	Fifteen	42 9	41 8	41 0	40 5	46 1
16	Sixteen	42 0	41 4	40 3		45 5
17	Seventeen	41 5	40 8	39 7		44.4
18	Eighteen	40 8	40 0	39 2		42 9
19	Nineteen	40 5	39 2	38 8		42.2
20	Twenty	39 9	38 6	38 4		41 6
21	Twenty-five	38 4	37 5	37 1		40 3
22	Thirty	37 6	36 8	36 4		39 6
23	Thirty-five	36 9	36 5	35 9		38 9
24	Forty	36 5	36 3	35 5		38 3
25	Forty five	36 3	36.2	34 3[6]		37 6
26	Fifty	36 0	35 8	33 9[6]		37 0
27	Fifty five	35.4	35.4	33 6[6]		36 3
28	Sixty	34 8	34 9	33 2[6]		35 7
29	Sixty-five	34 0	34.4	32 8[6]		35 1[8]
30	Seventy	33 1	33 8	32 6[6]		34 7[8]
31	Seventy five[7]	31 8	[illegible]	32 0		33 4[8]

/1/ Present H B D values (cf tab ... on ... D F and values
from Harris and Benedict 1919 /2/ ... from ... the
including those in cols E F of this ... of
/3/ The British Standard These

149 COMPARISON OF STANDARDS OF BASAL METABOLISM MAN

est of those given for children Adult values in columns B and C are so similar that either standard can be used safely in clinical medicine For children, choice between columns E or C and columns B or D will depend on the experience of the testing laboratory Some laboratories (even some technicians) tend to find higher basal values and some laboratories, lower Each laboratory may accordingly develop its own standard A variation of as much as 14% above or below the standard may occur in healthy persons (estimate "b , d of the ordinary range)

Line No	Age yr	Females				
		Boothby[1] 1952	Fleisch[2] 1951	Robertson and Reid[3] 1952	Lewis Duval and Iliff[4] 1943	Boothby Berkson and Dunn[5] 1936
		Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr
	(A)	(B)	(C)	(D)	(E)	(F)
1	One		53 0			
2	Two		52 4		52 9	
3	Three	54 5	51 2	54 5	51 3	
4	Four	53 9	49 8	53 9	49 9	
5	Five	53 0	48.4	53 0	48 4	
6	Six	51 2	47 0	51 8	46 9	50 5
7	Seven	49 7	45 4	50 2	45 5	48 5
8	Eight	48 0	43 8	48 4	44 0	46 7
9	Nine	46.2	42 8	46 4	42 7	46 1
10	Ten	44 9	42 5	44 3	41 4	45 7
11	Eleven	43 5	42 0	42 4	40 4	45 1
12	Twelve	42 0	41 3	40 6	39 7	43 9
13	Thirteen	40 5	40 3	39 1	38 4	42 5
14	Fourteen	39 2	39 2	37 8	36 8	41 1
15	Fifteen	38 3	37 9	36 8	35 2	39 7
16	Sixteen	37 2	36 9	36 0		38 6
17	Seventeen	36 4	36 3	35 3		37 6
18	Eighteen	35 8	35 9	34 9		37 0
19	Nineteen	35 4	35 5	34 5		36 6
20	Twenty	35 3	35 3	34 3		36 3
21	Twenty five	35 1	35 2	34 0		36 0
22	Thirty	35 0	35 1	34 1		35 8
23	Thirty five	34 8	35 0	33 5		35 7
24	Forty	34 3	34 9	32 6[6]		35 5
25	Forty five	33 9	34 5	32 4[6]		35 3
26	Fifty	33.4	33 9	32 1[6]		34.4
27	Fifty-five	32 9	33 3	31 8[6]		33 4
28	Sixty	32.4	32 7	31.4[6]		32 8
29	Sixty five	31 8	32 2	31 2[6]		32 4
30	Seventy	31 3	31 7	30 8[6]		32 2
31	Seventy-five[7]	31 1[9]	31 3	30 5[9]		32 0[8]

/4/ These values constitute part of the basis for those in Col C /5/ These values constitute part of the basis for those in cols B and C /6/ Interpolated Original data given for pentades 40-44 45-49, etc /7/ Values are for age 75 or over /8/ Extrapolated by authors /9/ Extrapolated.

Values are for adults

	Species	Body Weight	Body Surface[1]	Basal Metabolism Calories/day[2]		
		kg	sq m	Total[3]	per sq m	per $kg^{0\ 75}$
	(A)	(B)	(C)	(D)	(E)	(F)
1	Man ♂	65	1 83	1667	910	73
2	Man ♀	57	1 63	1347	828	65
3	Baboon	6 23	0 421	300	761	77
4	Cattle	366	4 56	5678	1245	68
5	Chicken	2 58	0 163	138	740	68
6	Chimpanzee	38	1 13	1111	986	73
7	Dog	14 9	0 652	542	831	72
8	Goat	36	1 09	747	683	51
9	Goose	5 0	0 292	276	945	82
10	Guinea pig	0 758	0 0687	48	700	59
11	Monkey, rhesus	3 22	0 257	156	608	65
12	Mouse	0 0285	0 00704	5 20	739	75
13	Pig	186	2 67	2647	993	52
14	Rabbit	3 5	0 198	160	809	62
15	Rat	0 300	0 0384	26	686	65
16	Sheep	30	0 805	692	860	55

/1/ Surface area calculated in sq cm from following equations in which W = body weight in grams: man (♂or♀), 3 81 $W^{0\ 425}$ x $H^{0\ 725}$ (where H = height in cm), baboon, 11 7 $W^{0\ 667}$, cattle, 15 82 $W^{0\ 625}$, chicken, 9 85 $W^{0\ 67}$ or 5 86 $W^{0\ 5}$ x $L^{0\ 6}$ (where L = rump to shoulder length in cm); chimpanzee, 10 $W^{0\ 667}$ (assumed), dog, 11 2 $W^{0\ 667}$; goat, 10 $W^{0\ 667}$ (assumed); goose, 10 $W^{0\ 67}$ (assumed) guinea pig, 9 85 $W^{0\ 64}$ monkey, rhesus, 11 7 $W^{0\ 667}$, mouse, 15 18 $W^{0\ 458}$ pig, 12 24 $W^{0\ 633}$; rabbit, 56 33 $W^{0\ 436}$ rat, 12 54 $W^{0\ 60}$ sheep, 8 5 $W^{0\ 667}$ /2/ In kilocalories /3/ For entire organism

151 BASAL AND RESTING ENERGY METABOLISM BEEF CATTLE

"Resting metabolism"[1] refers to heat production when the animal is at rest in a recumbent position before the morning feeding and under customary farm conditions The measurements are not taken in strictly thermo-neutral environment nor in the post-absorptive conditions The resting metabolism as thus defined is considerably above the basal metabolism the exact value depending on the nature of the diet the time after feeding and the environmental temperature

	Hereford Breed								
	Approximate Age	Body Weight	Body Surface Area[2]	Resting Metabolism[1,3,4]		Oxygen Consumption[5]	Basal Metabolism[3,6,7]		Oxygen Consumption[5]
		kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Males								
1	1.0 mo	40	1.02	53 9	2104	11.2			
2	1.3 mo	50	1.16	49.6	2137	10.3			
3	1.6 mo	60	1.29	46.4	2165	9 6			
4	1.8 mo	70	1.40	43.8	2188	9.1			
5	2.0 mo	80	1.51	41.7	2208	8.6			
6	2.5 mo	90	1.61	39 9	2227	8.3			
7	3.0 mo	100	1.71	38.4	2243	8.0			
8	6.0 mo	150	2.15	33.0	2304	6 9			
9	7.0 mo	200	2.53	29 7	2352	6.2			
10	9.0 mo	250	2 86	27.4	2389	5.7			
11	11.0 mo	300	3.17	25.6	2420	5.3			
12	1.1 yr	350	3.46	24.2	2444	5.0			
13	1.3 yr	400	3 72	23.0	2471	4.8			
14	1.5 yr	450	3 97	22.0	2491	4 6			
15	1.7 yr	500	4.21	21.2	2513	4.4			
	Females								
16		40	1.02	61.8	2511	12.8			
17		50	1.16	55 7	2398	11.5			
18	1.8 mo	60	1.29	51.1	2386	10.6			
19	2.5 mo	70	1.40	47.6	2376	9 9			
20	3 0 mo	80	1.51	44.7	2364	9.3			
21	4.0 mo	90	1.61	42.3	2361	8.8			
22	5.0 mo	100	1.71	40.3	2354	8.4			
23	6.5 mo	150	2.15	33.4	2326	6.9	22.2	1551	4.6
24	9.0 mo	200	2.53	29.2	2310	6.1	19 9	1573	4.1
25	11.0 mo	250	2.86	26.3	2296	5.5	18.2	1594	3 8
26	1.2 yr	300	3.17	24.1	2286	5.0	27 0	1610	3.5
27	1.4 yr	350	3.46	22.5	2275	4.7	16.0	1630	3 3
28	1.7 yr	400	3 72	21.1	2270	4.4	15 2	1635	3.2
29	2.0 yr	450	3.97	20.0	2136	4.1	14.5	1646	3 0

/1/ For techniques employed and underlying assumptions see Mo. Agr Exp. Sta. Res Bull. 404 /2/ Surface area based on equation Surface Area in sq. meters 0.15 (weight in kg)$^{0.56}$ /3/ In kilocalories /4/ For males data based on equation, Y 211 $X^{0.63}$; for females Y = 545 $X^{0.55}$; where Y resting metabolism in Calories/day and X body weight in kg. /5/ Standard temperature and pressure. /6/ For females data based on equation, Y 154 $X^{0.61}$ where Y basal metabolism in Calories/day and X body weight in kg. /7/ The "basal metabolism" is calculated from the observed oxygen consumption of the resting animal measured at frequent intervals after feeding until it becomes roughly constant i until after the specific dynamic effect" has ended (about 8 days after the last feeding)

152 RESTING ENERGY METABOLISM DAIRY CATTLE

Resting metabolism[1] refers to heat production when the animal is at rest in a recumbent position, before the morning feeding and under customary farm conditions The measurements are not taken in a strictly thermo-neutral environment nor in the post absorptive condition. The resting metabolism, as thus defined is considerably above the basal metabolism, the exact value depending on the nature of the diet the time after feeding and the environmental temperature

	Holstein and Jersey Breeds Females Only									
	Approximate Age		Body Weight	Body Surface Area[2]	Resting Metabolism[3,4]		Oxygen Consumption[5]	Resting Metabolism[3,4]		Oxygen Consumption[5]
			kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	Holstein Females	Jersey Females	Holstein and Jersey Females		Holstein Females			Jersey Females		
1		0 5 mo	25	0 92				52.1	1420	10 8
2	0.4 mo		40	1 17	46 9	1600	9 7			
3	1.1 mo	1 6 mo	50	1.34	45 1	1700	9 3	47 3	1770	9 8
4	3 8 mo	5 5 mo	100	1.92	39 7	2060	8 2	39.1	2050	8 0
5	6 0 mo	8 1 mo	150	2.45	34.4	2100	7 1	32.8	2010	6 8
6	8 2 mo	1 0 yr	200	2 89	30 6	2130	6 3	29 0	1990	6 0
7	11 5 mo	1 3 yr	250	3 25	28.0	2120	5 8	26.2	2020	5.4
8	1 2 yr	1 6 yr	300	3 60	26 0	2170	5.4	24 1	2010	5 0
9	1.4 yr	1.9 yr	350	4 02	24.4	2140	5 1	22.6	1960	4 7
10	1 6 yr	2.1 yr	400	4 33	23 1	2160	4 8	21.2	1940	4.4
11	1.8 yr		450	4 60	22.1	2160	4 6	20 2		4 2
12	2 0 yr		500	5 01	21.1	2180	4.4	19 3		4 0
13			550		20 3		4 2			
14			600		19 7		4.1			

/1/ For techniques employed and underlying assumptions see Mo Agr Exp Sta. Res Bull 335 and 350 /2/ Surface area based on equation, Surface Area in sq meters = 0 15 (weight in kg)$^{0\ 56}$ See Mo Agr Exp Res. Bull 89 p 10 /3/ In kilocalories /4/ For Holstein females up to approximately 150 kg data based on equation, $Y = 93\ X^{0\ 81}$ over 150 kg $Y = 259\ X^{0\ 60}$; for Jersey females up to 100 kg $Y = 99\ 3\ X^{0\ 84}$ over 100 kg $Y = 295\ X^{0\ 56}$, where Y = resting metabolism in Calories/day and X = body weight in kg /5/ Standard temperature and pressure

153 RESTING ENERGY METABOLISM GOATS

Resting metabolism[1] refers to heat production when the animal is at rest in a recumbent position, although neither in a strictly thermo-neutral environment nor in a post-absorptive condition It is measured before the morning feeding under customary farm conditions The resting metabolism, as thus defined, is considerably greater than the basal metabolism, the exact value depending on the nature of the diet, the time after feeding, and the environmental temperature

Toggenburg and Angora Goats[2]

	Body Weight (♂ or ♀) kg	Resting Metabolism[3,4] Cal/kg/day		Body Weight (♂ or ♀) kg	Resting Metabolism[3,4] Cal/kg/day		Body Weight (♂ or ♀) kg	Resting Metabolism[3,4] Cal/kg/day
	(A)	(B)		(A)	(B)		(A)	(B)
1	2	♂132 ♀124	9	18	♂65 ♀54	16	35	♂52; ♀44
2	4	♂106; ♀97	10	20	♂63 ♀54	17	40	♂50; ♀42
3	6	♂93; ♀84				18	45	♂48; ♀40
4	8	♂85; ♀75	11	22	♂61; ♀52	19	50	♂47; ♀39
5	10	♂79; ♀70	12	24	♂59; ♀51	20	55	♂45 ♀38
			13	26	♂58 ♀49			
6	12	♂74 ♀65	14	28	♂56 ♀48	21	60	♂44 ♀36
7	14	♂71; ♀62	15	30	♂55; ♀47	22	65	♂43 ♀35
8	16	♂68; ♀59				23	70	♂42; ♀34

/1/ For techniques employed and underlying assumptions see Mo Agr Exp Sta Res Bull 291 /2/ Sixteen Toggenburg and six Angora goats /3/ In kilocalories /4/ For males data based on equation, $Y = 166\ X^{0.676}$, and for females, $Y = 160\ X^{0.638}$, where Y = resting metabolism in Cal/day and X = body weight in kg

154 BASAL AND RESTING ENERGY METABOLISM: GUINEA PIGS

Basal metabolism[1] is calculated from the 24-48 hour fasting oxygen consumption of the resting animal. Resting metabolism[1] is affected by the calorigenic action of the food. Measurements were made at about 30° considered to be thermoneutral for the animal. Values are from smoothed plotted curves based on tabular data and curves in the original source publication.

	Approximate Age		Body Weight	Surface Area[2]	Resting Metabolism[1]			
	(A)	(B)	kg (C)	sq m (D)	Cal/kg/day (E)	Cal/kg/day (F)	Cal/sq m/day (G)	Cal/sq m/day (H)
	Males	Females	Males & Females	Males & Females	Males	Females	Males	Females
1	Birth		0.080	0.0164	154	160	731	781
2	2 da		0.100	0.0188	150	154	798	819
3	19 da		0.150	0.0243	138	128	753	780
4	30 da		0.200	0.0293	114	118	778	805
5	75 da	80 da	0.400	0.0456	91	96	798	835
6	137 da	154 da	0.600	0.0591	75	77	761	822
7	290 da	270 da	0.800	0.0710	63	68	710	766
8			0.900	0.0766	57	66	690	773
9			1.000	0.0819	54	63	659	769

	Approximate Age		Body Weight[3]	Surface Area[2]	Basal Metabolism[1]			
	(I)	(J)	kg (K)	sq m (L)	Cal/kg/day (M)	Cal/kg/day (N)	Cal/sq m/day (O)	Cal/sq m/day (P)
	Males	Females	Males & Females	Males & Females	Males	Females	Males	Females
3	22		0.150	0.0243	117[4]	120[4]	722	711
4	36		0.200	0.0293	108	112	737	765
5	60	67	0.400	0.0456	86	90	754	789
6	145	170	0.600	0.0591	71	76	721	721
7			0.800	0.0710	60	63	676	710
8			0.900	0.0766	57		670	
9			1.000	0.0819	54		659	

/1/ See source publication for underlying assumptions and techniques. /2/ Data based on equation Surface Area in square centimeters = 9.85 (body weight in grams)$^{0.64}$ /3/ Weights have been affected by 24-48 hrs of fasting and are accordingly lower than the normal weights of the animals. /4/ By extrapolation of smoothed curve.

155 RESTING ENERGY METABOLISM HORSES

Resting metabolism[1] refers to heat production when the animal is at rest in a recumbent position, although neither in a strictly thermo-neutral environment nor in a post absorptive condition It is measured before the morning feeding under customary farm conditions The resting metabolism, as thus defined, is considerably greater than the basal metabolism, the exact value depending on the nature of the diet, the time after feeding, and the environmental temperature

Percheron Horses

	Approximate Age		Body Weight	Body Surface Area[2]	Resting Metabolism[3,4]		Oxygen Consumption[5]	Resting Metabolism[3,4]		Oxygen Consumption[5]
			kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(F)	(F)	(G)	(H)	(I)	(J)
	Males[6]	Females	Males[6] & Females		Males[6]			Females		
1	0 1 mo	0 1 mo	75	1 52	51 5	2540	10 7	51 3	2540	10 6
2	0 6 mo	0 7 mo	100	1 82	44 8	2460	9 3	45 0	2470	9 3
3	1 6 mo	1 6 mo	150	2 35	36 9	2360	7 6	37 3	2380	7 7
4	2 8 mo	2 9 mo	200	2 82	32 2	2280	6 7	32 7	2320	6 8
5	4 0 mo	4 0 mo	250	3 23	28 9	2230	6 0	29 5	2280	6 1
6	6 0 mo	6 0 mo	300	3 63	26 5	2180	5 5	27 1	2240	5 6
7	9 5 mo	8 5 mo	350	4 00	24 6	2150	5 0	25 3	2210	5 2
8	1 2 yr	1 2 yr	400	4 35	23 0	2120	4 8	23 8	2180	4 9
9	1 5 yr	1 5 yr	450	4 70	21 8	2090	4 5	22 5	2150	4 7
10	2 0 yr	1 9 yr	500	5 02	24 1	2400	5 0	24 9	2480	5 2
11	2 3 yr	2 2 yr	550	5.33	24 5	2530	5 1	24 8	2560	5 1
12	2 9 yr	2 4 yr	600	5 63	24 9	2650	5 2	24 8	2640	5 1
13	4 2 yr	2 8 yr	650	5 92	25 2	2770	5 2	24 7	2710	5 1
14	4 8 yr	3 3 yr	700	6 21	25 6	2880	5 3	24 6	2780	5 1
15		4.1 yr	750	6.47	25 9	3000	5 4	24 6	2850	5 1
16		5 0 yr	800	6 75	26 2	3100	5 4	24 5	2910	5 1

/1/ For techniques employed and underlying assumptions see Mo Agr Exp Sta Res Bull 368 /2/ Based on equation, Surface Area in sq meters = 0 1 (weight in kg)$^{0\ 63}$ See Mo Agr Exp, Sta. Res Bull 115, p 30 /3/ In kilocalories /4/ For weights up to 500 kg, data based on equation Y = 409 $X^{0\ 52}$, for males and Y = 374 $X^{0\ 54}$ for females For weights over 500 kg Y = 7 86 $X^{1\ 18}$ for males and Y = 30 $X^{0\ 97}$ for females Y = resting metabolism in Calories per day and X = body weight in kg /5/ Standard temperature and pressure /6/ Geldings

156 RESTING ENERGY METABOLISM MULES

Resting metabolism[1] measures the energy maintenance cost in the standing position after intermittent light feeding (grazing) No difference has been found between standing and recumbent metabolism records in horses over the entire period of growth

	Approximate Age	Body Weight	Body Surface Area[2]	Metabolism[3]		Oxygen Consumption[4]
		kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)
	Males and Females					
1	One week	60	1 35	60 5	2685	12 5
2	Three weeks	80	1.62	54 5	2686	11 3
3	Four weeks	100	1.87	50 3	2689	10.4
4	Six weeks	150	2.42	43 5	2693	9 0
5	Four months	200	2 91	39 2	2697	8 1
6	Six months	250	3 35	36 2	2698	7 5
7	Eight months	300	3 76	33 9	2701	7 0
8	Eleven months	350	4 15	32.1	2704	6 6
9	Thirteen months	400	4 52	30 6	2705	6 3
10	Eighteen months	450	4 87	29 3	2705	6 1
11	Twenty six mo	500	5 21	28 2	2706	5 8
12	Thirty six mo	550	5 53	27 2	2708	5 6
13	Thirty-eight mo	600	5 85	26.4	2709	5 5
14	Fifty months	650	6 15	25 6	2710	5.3
15	Five years	700	6.45	25 0	2710	5.2

/1/ For techniques employed and underlying assumption see Kibler, H H and Brody S Mo Agr Exp Sta. Res. Bull 438 1949 /2/ Based on equation Surface Area in sq meters = 0 1 (weight in kg)$^{0\ 636}$ See Mo Agr Exp. Sta. Res Bull 115 p 30 /3/ Kilocalories; data based on equation $Y = 264 X^{0\ 64}$ where Y = resting metabolism in Cal/day and X = body weight in kg /4/ Standard temperature and pressure

157 BASAL AND RESTING ENERGY METABOLISM: RATS

Values are read from smoothed curves based on tabular data and curves from the source publication[1]

Albino

	Approximate Age		Body Weight	Surface Area[2]	Resting Metabolism[3 4]			
			kg	sq m	Cal/kg/day		Cal/sq m/day	
	Males	Females	Males and Females	Males and Females	Males	Females	Males	Females
1	<1 da[7]		0 005	0 0030	340[7]		567[7]	
2	5 da		0 010	0 0047	290		617	
3	10 da		0,015	0 0060	200		500	
4	14 da		0,020	0 0073	205		562	
5	19 da		0 025	0 0084	216		643	
6	21 da		0 030	0,0094	233		744	
7	25 da		0 035	0 0103	257		873	
8	29 da		0,050	0 0129	280		1085	
9	35 da	36 da	0 075	0 0167	267		1199	
10	40 da	42 da	0,100	0 0200	260	240	1300	1200
11	49 da	54 da	0,150	0 0258	193	167	1122	972
12	60 da	120 da	0,200	0 0310	155	135	1000	871
13	82 da		0 250	0 0356	132		927	
14	100 da		0,300	0 0400	113		848	

Approximate Age		Body Weight[5]	Surface Area[2]	Basal Metabolism[4 6]			
		kg	sq m	Cal/kg/day		Cal/sq m/day	
Males	Females	Males and Females	Males and Females	Males	Females	Males	Females
31 da		0 050	0 0129	240		930	
37 da	38 da	0 075	0 0167	227		1019	
42 da	45 da	0,100	0 0200	210		1050	
52 da	62 da	0 150	0 0258	160	153	930	890
64 da	140 da	0 200	0 0310	140	116[7]	903	761[7]
87 da		0,250	0 0356	124		871	
120 da		0 300	0 0400	107		802	

/1/ See source publication for underlying assumptions and techniques /2/ Data based on equation Surface Area in sq meters = 0 0011 (body weight in grams)$^{0\ 65}$ /3/ Authors "day to-day" metabolism. Method permitted observation of animals activity thus eliminating from the results any values affected by activity /4/ Kilocalories /5/ Weights have been affected by 14-20 hrs of fasting and are accordingly lower than the normal weights of the animals /6/ Basal metabolism calculated from 14-20 hour fasting oxygen consumption of the resting animal /7/ By extrapolation of smoothed curve

158 RESTING AND FASTING ENERGY METABOLISM SWINE

"Resting metabolism"[1] refers to heat production when the animal is at rest in a recumbent position, though not in a strictly thermo-neutral environment nor in post-absorptive condition but as measured before the morning feeding under customary farm conditions. The resting metabolism as defined is considerably above the basal metabolism, the exact value depending on the nature of the diet, on time after feeding and on environmental temperature. Fasting metabolism[1] = 24-hr fasting; does not necessarily represent basal metabolism.

	Approximate Age	Body Weight	Body Surface Area[2]	Duroc Jersey Swine			Chester White Swine			Duroc Jersey and Chester White Swine		
				Resting Metabolism[3,4]		Oxygen Consumption[5]	Resting Metabolism[3,6]		Oxygen Consumption[5]	24-hr Fasting Metabolism[3,7]		Oxygen Consumption[5]
		kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
	Males											
1	1.5 mo	5	0.27	77.2	1440	16.0	77.2	1440	16.0			
2	3.3 mo	10	0.42	67.6	1620	14.0	67.6	1620	14.0			
3	4.3 mo	15	0.54	64.3	1790	13.3	64.3	1790	13.3	41.8	1260	8.7
4	5.0 mo	20	0.65	62.7	1940	13.0	62.7	1940	13.0	41.0	1270	8.5
5	5.5 mo	25	0.75	61.8	2070	12.8	61.8	2070	12.8	38.6	1300	8.0
6	7.3 mo	50	1.15	57.9	2510	12.0	57.9	2510	12.0	33.8	1460	7.0
7	9.4 mo	75	1.49	37.3	1880	7.7	41.2	2070	8.5	30.9	1590	6.4
8	11.0 mo	100	1.79	33.8	1890	7.0	38.6	2160	8.0	26.5	1480	5.9
9	1.3 yr	150	2.31	28.9	1880	6.0	35.1	2270	7.3	21.9	1420	4.8
10	1.8 yr	200	2.78	25.8	1860	5.3	32.8	2360	6.8	19.3	1370	4.0
11	2.1 yr	250	3.19	23.7	1880	4.9	31.1	2430	6.4	17.4	1360	3.6
	Females											
12	1.5 mo	5	0.27	77.2	1440	16.0	77.2	1440	16.0			
13	3.0 mo	10	0.42	72.4	1740	15.0	72.4	1740	15.0	43.4	1040	9.0
14	4.0 mo	15	0.54	67.5	1880	14.0	67.5	1880	14.0	38.6	1060	8.0
15	4.7 mo	20	0.65	67.6	2090	14.0	67.6	2090	14.0	38.6	1190	8.0
16	5.1 mo	25	0.74	65.6	2210	13.6	65.6	2200	13.6	36.7	1230	7.6
17	6.6 mo	50	1.16	60.8	2630	12.6	60.8	2630	12.6	31.8	1380	6.6
18	8.3 mo	75	1.49	40.5	2040	8.4	40.5	2040	8.4	30.2	1520	6.3
19	10.0 mo	100	1.79	33.3	1860	6.9	36.2	2020	7.5	23.2	1290	4.8
20	1.1 yr	150	2.31	25.1	1627	5.2	30.6	1980	6.3	18.7	1210	3.9
21	1.5 yr	200	2.77	20.8	1900	4.3	27.3	1960	5.6	15.9	1150	3.3
22	2.1 yr	250	3.19	17.8	1390	3.7	25.1	1960	5.2	14.1	1100	2.9

/1/ For techniques employed and underlying assumptions see Brody S and Kibler H H, Mo Agr Exp Sta Res Bull 380 1944 /2/ Based on equation, Surface Area in sq meters = 0 097 (weight in kg)$^{0.633}$ See Mo Agr Exp Sta Res Bull 115 p 30 /3/ In kilocalorie /4/ Up to 50 kg, for males data based on equation Y = 88.1 $X^{0.89}$ and for females Y = 89 9 $X^{0.90}$; over 50 kg, for males Y = 194 $X^{0.60}$ and for female Y = 704 $X^{0.32}$ where Y = resting metabolism in Calories/day and X = body weight in kg /5/ Standard temperature and pressure /6/ Up to 50 kg, for males data based on equation Y = 88 1 $X^{0.89}$ and for females, Y = 89 9 $X^{0.90}$; over 50 kg for males Y = 117 $X^{0.70}$ and for females Y = 228 $X^{0.60}$ where Y = resting metabolism in Calories/day and X = body weight in kg /7/ Up to 50 kg, for males data based on equation, Y = 73 4 $X^{0.80}$ and for females Y = 68 8 $X^{0.85}$; over 50 kg, for males Y = 221 $X^{0.54}$ and for females Y = 295 $X^{0.45}$ where Y = 24-hr fasting metabolism in Calories/day and X = body weight in kg

159 RESTING AND FASTING ENERGY METABOLISM CHICKENS

Values are read from smoothed curves based on tabular data and curves in the original source publication[1]

	Approximate Age		Body Weight	Surface Area[2]	Resting Metabolism[3] [4]				Approximate Age		Body Weight[5]	Surface Area[2]	Fasting Metabolism[4] [6]			
			kg	sq m	Cal/kg/day		Cal/sq m/day				kg	sq m	Cal/kg/day		Cal/sq m/day	
	(A) Males	(B) Females	(C) Males & Females	(D) Males & Females	(E) Males	(F) Females	(G) Males	(H) Females	(I) Males	(J) Females	(K) Males & Females	(L) Males & Females	(M) Males	(N) Females	(O) Males	(P) Females
					Rhode Island Red											
1	Hatching	Hatching	0 040	0.011	200		727									
2	5 da	7 da	0 050	0 013	210		808									
3	15 da	20 da	0 100	0.021	220		1048									
4	20 da	25 da	0 150	0 028	215		1152									
5	25 da	31 da	0.200	0 034	205		1206									
6	29 da	35 da	0.250	0 040	202	180	1263	1125								
7	52 da	59 da	0 500	0.065	120	114	923	877	55[7] da	64[7] da	0 500	0 065	84[7]	100[7]	646[7]	769[7]
8	82 da	94 da	1.000	0 107	100	95	935	888	86 da	100 da	1 000	0 107	80	78	748	729
9	101 da	125 da	1 500	0 142	90	83	951	877	105 da	150 da	1 500	0 142	77	67	813	708
10	129 da	200 da	2 000	0 174	90	77	1034	885	131 da	250 da	2 000	0 174	75	60	862	690
11	160 da	>365 da	2 500	0.204	88	72	1078	882	166 da	>365 da	2 500	0 204	72	56	882	686

/1/ See source publication for underlying assumptions and technique /2/ Data based on equation Surface Area in square centimeters = 8 19 (body weight in grams)$^{0.705}$ /3/ Method permitted observation of animals activity, thus allowing elimination from the results such values that may have been affected by any activity /4/ Kilocalories /5/ Weights have been affected by 24 hrs of fasting and are accordingly lower than the normal weights of the animals /6/ Fasting metabolism calculated from 24 hour fasting oxygen consumption of the resting animal /7/ By extrapolation on smoothed curve

160 METABOLIC RATES SOIL ORGANISMS

(See next page for columns G-K of this table)

In columns B D F I the following symbols are used; μμ = a millionth of a millionth (10^{-12}); μ = a millionth (10^{-6}); m = a thousandth (10^{-3}); M million (10^{6}) Values in columns I J K are included to indicate order of magnitude of the metabolic activity of populations

	Groups and Species	Weight	Temperature[1]	Metabolic Rate: Calories[2]	Metabolic Rate: Calories[2]	Metabolic Rate: O_2 Consumption
		mg	C	Cal/hr/ind[3]	Cal/hr/ind[3]	ml/hr/ind[3]
	(A)	(B)	(C)	(D)	(E)	(F)
1	Bacteria					
2	Sarcina lutea	1,000 μμ	20 5	33 m μμ	33	7 μμ
3	Fungi					
4	Mycoderma sp	100 000 μμ	20 0	0 024 m μ	258	4 950 μμ
5	Saccharomyces sp	180 000 μμ	20 0	8 7 μμ	48 1	1 790 μμ
6	Protozoa					
7	Chaos chaos (amoeba)	0 05	22 5	42-62 m μ	0.83-1.24	8.6-12 9 μ
8	Nematoda					
9	Monhystera	0 2-0 3	16 0	1.45-2 17 μ	6.14-8 34	300-450 μ
10	Plectus	0 5-1.0	16 0	2 9-5.8 μ	4.8-6.8	600-1,200 μ
11	Dorylaimus	0 3-56	16 0	1 93-216 μ	2.4-5 3	400-44 800 μ
12	Annelida					
13	Lumbricus terrestris (earthworm)	500	17-20	0.145 m	0.29	0 05
14	Lumbricus terrestris (earthworm)	5 000	20-23	1.45 m	0.29	0 3
15	Lumbricus terrestris (earthworm)	1 210	13 0	0.424 m	0 35	0 09
16	Mollusca					
17	Helix aspersa (garden snail)	10 000	10 0	2 06 m	0.206	0.426
18	Helix aspersa (garden snail)	10 000	20 0	4.24 m	0.424	0.876
19	Acari					
20	Oribatei					
21	Euzetes aterrimus	0.25	14 5	150-193 m μ	0.6-0 77	31-40 μ
22	Notaspis coleoptratus	0 05	11.5	48 3 m μ	1 59	10 μ
23	Parasitiformes					
24	Macrocheles sp	0.25	12 0	483 m μ	1.93	100 μ
25	Araneae					
26	Lycosa sp	15.1	13 0	33 2 μ	2.2	6 870 μ
27	Opiliones					
28	Nemastoma sp	3 8	13 0	9.17 μ	2.415	1,900 μ
29	Coleoptera					
30	Carabus nemoralis (ground beetle)	644	13 0	767 μ	1.19	0 159
31	Staphilinus olens (rove beetle)	247	13 0	285 μ	1.15	0 059
32	Epaphius secalis (ground beetle)	1.2-2.2	13 0	7 9 8 μ	3 92	1 500-2 000 μ
33	Notiophilus biguttatus (ground beetle)	7 3	13 0	36 μ	4 8	7 600 μ
34	Diptera					
35	Tipula sp (larva)	277	13 0	285 μ	1.05	0 059
36	Tipula sp (larva)	607	13 0	502 μ	0.825	0 104
37	Collembola					
38	Pogonognathus plumbeus	1.3-2 5	13 0	6 5-9 3 μ	5 02 3 7	1,400-1 900 μ
39	Orchesella flavescens	1.8-3 5	13 0	5 3-11.7 μ	2 95-3 34	1,100-2 400 μ

/1/ Temperature used in determining values in columns D-G Values in column K are reduced to the common standard of 16 C according to Krogh curve /2/ Kilocalories /3/ Individual.

160 METABOLIC RATES SOIL ORGANISMS (Concluded)

(See preceding page for columns B-F of this table)

In columns B D F I the following symbols are used: μμ = a millionth of a millionth (10^{-12}); μ = a millionth (10^{-6}); m = a thousandth (10^{-3}); M = million (10^{6}) Values in columns I J K are included to indicate order of magnitude of the metabolic activity of populations

	Groups and Species	Metabolic Rate (Concluded)	Respiratory Quotient[3]	Typical Estimates Natural Soils[4]		
		O_2 Consumption		Number	Mass	Metabolism
		L/kg/hr		Per sq m	g/sq m	Cal/hr/sq m[2]
	(A)	(G)	(H)	(I)	(J)	(K)
1	Bacteria			200-1,200 MM	200-1,200	550 m
2	Sarcina lutea	7	0 71			
3	Fungi				40-400	
4	Mycoderma sp	49	(0 82)			
5	Saccharomyces sp	10	(0.82)			
6	Protozoa			100-500 M	38	21-32 m
7	Chaos chaos (amoeba)	0.17-0.25	(0 82)			
8	Nematoda			0 175-20 M	0 7 17.8	4.2-107 m
9	Monhystera	1 3-1.7	0 85			
10	Plectus	1 1.4	0.85			
11	Dorylaimus	0 5-1.1	0 85			
12	Annelida			50-2 000	1 6	0.48 m
13	Lumbricus terrestris (earthworm)	0.06	(0.82)			
14	Lumbricus terrestris (earthworm)	0 06	(0.82)			
15	Lumbricus terrestris (earthworm)	0.075	(0 82)			
16	Mollusca			0-8,500	0-50	0-15 m
17	Helix aspersa (garden snail)	0 043	(0.82)			
18	Helix aspersa (garden snail)	0 088	(0.82)			
19	Acari				4 5	6 75 m
20	Oribatei			2,100-121 000	0 07-0.85	0.105-1.24 m
21	Damaeus aterrimus	0.124-0.16	(0.82)			
22	Notaspis coleoptratus	0 55	(0.82)			
23	Parasitiformes			200-7 400	0 09-0.22	0.15-0 33 m
24	Macrocheles sp	0.4	(0.82)			
25	Araneae			175-637	0 637	0 39-1.4 m
26	Lycosa sp	0.455	(0.82)			
27	Opilliones			1.6-38	0 005-0.148	0 016-0.47 m
28	Nemastoma sp	0 5				
29	Coleoptera				3.8	6.1 m
30	Carabus nemoralis (ground beetle)	0.247	(0 82)			
31	Staphilinus olens (rove beetle)	0.259	(0 82)			
32	Ebaphium sexalis (ground beetle)	1.225	(0.82)			
33	Notiophilus biguttatus (ground beetle)	0.878	(0.82)			
34	Diptera				1 0	1.55 m
35	Tipula sp (larva)	0.214	(0 81)			
36	Tipula sp (larva)	0 171	(0.82)			
37	Collembola			40-40 000	6.85	27-46 m
38	Pogonognathus plumbeus	0 768-1.04				
39	Orchesella flavescens	0.606-0.691				

/2/ Kilocalories /3/ O_2 consumed ÷ CO_2 liberated. Values in parenthesis are assumed. The value 0.82, is usually assumed because this is the mean value for protein, and whatever the ratio of fat to carbohydrate in the food the values calculated will differ by no more than 3 5% from the true values /4/ Values are reasonably accurate estimates from the literature and represent mean annual abundance Bacteria values unreliable

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The following abbreviations are used Fn = footnote Calc fr = calculated from; Av = average

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Reviewers Bahorn F E.; Beeson, W M.; Berg C P; Bird H. R.; Blinks L. R.; Bohstedt G; Burris R. H.; Burström, H; Castino E. C.; Chaldalis, V E.; Clark F M.; Combs G. F; Cocuzza F; Danforth W; Daniel L. J; Dewey V C; El-Anl A.; Elliott A. M.; Evans R. J; Fagg G. E.; Foster J W; Frenkel A.; Gordon H. T; Halver J E.; Hansard S. L.; Hanson R. W; Hoskins R. H.; Haynes W C; Henderson, L. M.; Hibbs J W; Hula G. G; Jr; House H. L.; Jamieson, M. Kidder G. W; Knorr S. A.; Ledingham, G. A.; Lindegren, C C; Loefer J B.; MacVicar R. W; Matchett J R.; Mills Minarik C. E.; Moore, W B.; Naish A. C; Nickerson W J; Nightingale G. T; Noland J L.; Norris L. C; Paretsky D. Pelletier R. L.; Perlman, D.; Pomerene E.; Porges N.; Procter B. E.; Purvis E. R.; Robbins W R.; Rosoff L. L.; Schaefer A. E.; Scott M. L.; Shive J W; Shorb M. S.; Sun P; Simpson F J; Steinberg R. A.; Tatum, E. L.; Tatman, E. V; Thomas J W; Trager W; Turrell F M.; Vishniac H. S.; White P R.; Wickerham, L. J; Wolf F T

8 NUTRIENTS GENERAL CARBON SOURCES

Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
1 15 B 1 15 C 1 15 D	1 2 3 4,5,6 [4-11]	1 15 E 1 15 F 1 15 G	[8-11] 12 [12-16]	1 15 H 1 15 I 1 15 K	[13-16] 17,18 [19-22]

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(Continued on the next page)

57 DAILY NUTRIENT ALLOWANCES: FOX AND MINK

Data Coordinates and Footnotes	Contributors and References
2 FG BD	Calc. fr 1a
6,14,26,37 B-Q	1a
All other values	Calc. fr 1 by b

Contributors: (a) Harris L. E. (b) Miller D. F

References: (1) Forthcoming Report of the Committee on Animal Nutrition, National Research Council.

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58 DAILY NUTRIENT ALLOWANCES: HORSE

Contributor: ( ) Pearson, P B.

References: (1) Values in this table calculated and adapted from forthcoming Report of the Committee on Animal Nutrition, National Research Council, by Pearson, P B. Winchester C. F and Harvey A. L.

Reviewers Cupps P T; Leaton A. L.; Mitchell H. H.; Norris L. C; Pearson, P B.; Schneider B. H.; Winchester C.

59. DAILY NUTRIENT ALLOWANCES: MONKEY

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
2 B	1a	15 B	15a	23 B	8a,8a
2 39 C	b	16 B	3a 4b 4a 5a	24 B	9b,9a,10a
9 B	2b	16 C	16a	25 B	14b
10 B	8a 11b	19 B	6a	Fn 3	
11 B	12b	20,22 B	7b	Fn 14	
14 B	13a				

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60. DAILY NUTRIENT ALLOWANCES: RAT

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-F	b	14 EF	b	21 EF	b
2 BCD	Calc fr 11	15 B	a	22,23 B E	
3 BCD	a	15 CD	1a	22,23 C	6a
4 B-F	b	15 EF		22-24 D	1a
5 B DEF	b	16 BCD	1a	22 F	8a
5 C	5a	16 EF	b	23 F	9a
6 7 B-F & Fn 1	b	Fn 6	3a,4a	24 B	
8 B-F	10	17 B-F	b	24 C	7a
9-11 BCD	1a	Fn 7	8da,8da	24 EF	10
9-11 EF	b	18,19 BCD	1a	25,26 B F	Calc fr 10
12 B		18,19 EF	b	27 B F & Fn 11	b
12 CD	1a	20 BC	a	28-38 BCDEF	Calc fr 10
12 E		20 D	1a	39 BC	Calc fr 10
12 F	10	20 EF		39 DEF	b
13 B-F & Fn 4	b	21 BCD	1a	Fn 12	b
14 BCD	1a	21 EF	b		

(Continued on the next page)

44. DAILY NUTRIENT ALLOWANCES: SWINE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
2 3 5 7 9,10 B-E	1a	13,14 B-E & Fa 10	1a	Fa 17	2d
Fa 5	f	15 B-E & Fa 13	3d	22 B	
Fa 6	d	16 B	e	25-26,28,30-35 37 39 BCDE	1a
Fa 7	b	Fa 15	1	Fa 20	1
12 B & Fa 8	1a 4d	19,20 B-E	1a		

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References: (1) Calculated from and in agreement with values in forthcoming Report of the Committee on Animal Nutrition, National Research Council (2) Luecke R. W et al J Nutrition 36 417 1948. (3) Ainstone F R. et al. Am. J Anim Sci 8:260 1949 (4) Brahmin, R. O and Johnson, B C J Nutrition 41 149 1950

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45. DAILY NUTRIENT ALLOWANCES CHICKEN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D-K	2f	16 B	1a,1e	26 D I	f
1 C	2e	16 C H	f	28 B G	1a
2 B DEF	2e	16 K	d	28 C H	2f
3 BC	1aef	16 G	1a 7b	30 BD EF	1a,1e
3 D-K	1a	18 B	1e	30 GH JK	1a
4 B EFG IJ	2e	18 C K	2f	31 BC GH	2f
5 BC	1aef	18 G	1a	32 B	1a,1e
5 DEF IJK	1a	19 B	1a,1e,1f	32 C H	2f
5 GH	1f	19 C H	2f	32 G	1a
6 B E-J	2e	19 G	1a	33 B	1e
7 B-K	2f	20 B-F	1a,1e	33 EFG K	1a
9 B-K	1aefg	20 G JK	1a	34 B-F	1a
11 B	1aef	20 H	1a,2f	34 G-K	1a
11 C E H J	ef	22 B D-G JK	1a,1	35 BC	1e
11 FG K	1a	22 C H	2f	35 GH	1a
12 B D	1a	23 B-F	1a,1e	37 B-F	1
12 C EF H JK	2f	23 G-K	1a	37 G-K	1a
13 B G	3e,6e	24 BC GH	2f	Fa 1,2,3	2f
13 F	6e	25 BCD	1e,1f	Fa 5,8	f
13 K	5e	25 E-K	1a	Fa 7,11	b
14 B-K	1a,1e	26 BC E-H JK	g	Fa 12,14	d
15 BC GH	2f				

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46 DAILY NUTRIENT ALLOWANCES TURKEY

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
3 5 9,12,14,25,33 34 B	1a,1e	16 B	1a	25,34 CD	1e
3 C	1a	16 D	3b	26 BCD	
3 D	1a,2d	18 B	4d	Fa 10	,e
5 9 CD	1a	19,22 B	3b	Fa 11	
7 BCD	4d	20 B	1a	30,35 BCD	4d
9 CD	1a	20 CD	4d	33 B	1a
14 BCD	1a,1e	23 B D	1a,4d	34 CD	1e
		25 C	4d	37 BCD	1a

Contributors (a) Bird H R. (b) Johnson B. C ( ) Kratzer F H. (d) Bestler R. R. ( ) Scott M. L.

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47 DAILY NUTRIENT ALLOWANCES: FISH

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
5 B-I	11a	13 BC E	6a	19 D G	8a
5 F XI	12a	14 BCD F I	8a	19 F XI	6a
8 B-I	6a	14 E	1a	20 E	15b
9 BCD F I	8a	15 BC	4a	21 BC E	7a
9 E	13b	15 D F	8a	21 D F I	2a,14a
Fn 4	Calc fr 13 by 4	15 E	1a,4a	22 BC E	7a
10 BC E	3a	16 BC	1a	22 D F XI	8a,14a
10 D F I	8a,9a	16 D F	8a	23 BC E	6a
11 BCD F I	8a,14a	16 E	13b	23 D F E	9a
11 E	13b	18 BC E	3a	25 G	8a
12 B-I	8a	18 F	8a,14a	25 I	10a
		19 BC E	7	29 B-I	15b

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References: (1) Wolf L. E. Prog. Fish Cult. 13:81 1951 (2) Halver J. E. unpublished research report Dept. of Int. Fish and Wildlife Service, 1950-51 (3) Phillips, A. M. Jr Fish. Res. Bull. Albany N. Y Conserv Dept. 10:9 1947 (4) Ibid., 12:3,1949. (5) Ibid. 6:7 1943. (6) Becker R. E. Johnson, E. E. and Hayton, O. M. Prog. Fish Cult. 14:10 1952. (7) Phillips, A. M. Jr et al. Fish. Res. Bull. Albany N. Y Conserv Dept. 6:11, 1944. (8) Ibid. 9:11, 1946. (9) Donaldson, L. R. School of Fisheries, Uni of Washington, Seattle, (unpublished) (10) Burrows, R. E. and Karrick, N. L. Ind. Res. and Dev Div Report No.1, 1947 (11) Phillips, A. M. Jr et al. Fish Res. Bull. Albany N. Y Conserv Dept. 11 7 1948. (12) Phillips, A. M. Jr U. S. Fish and Wildlife Service, Cortland, N. Y, 1951, (unpublished) (13) McLaren, B. A. Keller E. O'Donnell, J and Elvehjem, C. A. Arch. Biochem. 15:169, 1947 (14) Halver J. E. unpublished research report, Dept. of Int. Fish and Wildlife Service, 1951-1952. (15) Merino D J Exp Med. 19:70 1914

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48. DIETS LOW COST MAN U.S.A.

Data Coordinates and Footnotes	Contributors and References
1-19 B	1a
All others & Fn 1 2,3,11	2b

Contributors: (a) Krogman W M. (b) Phipard E. F

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49. DIETS MODERATE COST: MAN U.S.A.

Data Coordinates and Footnotes	Contributors and References
1-19 B	1a
All others & Fn 1, 2,3,11	2b

Contributors: ( ) Krogman W M. (b) Phipard, E. F

References: (1) Values calculated and adapted from Krogman W M. Growth of man Tabulae Biologicae Den Haag Netherlands: Uitgeverij Dr W Junk, 20 1941. (2) Values calculated and adapted from U S Dept Agriculture Miscellaneous Publication, No. 662 U. S. Dept. Agr 1950.

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50. DIETS LABORATORY AND DOMESTIC ANIMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 15 CDE	6	85,86,86-112 BCDE &		141,142 BCDE	
16-27 CDE	5	Fn 3,4	11h	143-150 BCDE	2d
28-41 BCDE	4 9f	113-118 CDE	8	151 164 CDE	7
42-62 BCDE	1a	119-132 CDE	6	165-176 CDE	4
63-82 CDE		133 C		177-209 BCDE	1a
		133-140 DE	b		

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References (1) Report of Committee on Animal Nutrition, National Research Council, Mar. 1950; adapted by Bird, H. R. (2) J Exp Zool. 65 557, 1933 (3) Archives of Biochemistry 15 151, New York: Academic Press Inc 1947 (4) Report of Committee on Animal Nutrition, 2, National Research Council, Aug., 1950. (5) Report of Committee on Animal Nutrition, 3, National Research Council, Aug., 1944. (6) Report of Committee on Animal Nutrition, 4, National Research Council, Dec., 1950 (7) Report of Committee on Animal Nutrition, 5, National Research Council, Aug., 1949. (8) Report of Committee on Animal Nutrition, 6, National Research Council, Mar., 1949 (9) Reyniers J A. et al. Lobund Reports, 1, Notre Dame Indiana: Univ of Notre Dame 1946 and Lobund Reports, 3, (in press) (10) Hogan, A. G. and Hamilton, J W J Nutrition 23:533, 1942. (11) Tunison, A. V Trout Feeds and Feeding, U S Dept. of Interior Feb 1945

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51 ZOO DIETS MAMMALS CARNIVORES

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52 ZOO DIETS; MAMMALS, HERBIVORES

References These data compiled and calculated from data contributed by ( ) Crosbie O Q (San Diego Zoological Gardens); (b) Goss L. J Goodall, C P and McClung, R. M., (New York Zoological Park); ( ) Luckey T D (Lincoln Park Zoo Chicago, Ill. M. Perkins Director)

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53 ZOO DIETS BIRDS

References These data compiled and calculated from data contributed by ( ) Goss L. J Goodall, C P and McClung, R. M. (New York Zoological Park) and (b) Crosbie O Q

Reviewers Beachley R. J Conway W G; Crosbie O Q Goodall, C P; Goss L. J; Luckey T D McClung, R. M.; Moss, M.; Ratcliffe H. L.; Vierheller G. P; Walker E. P

54 REPRESENTATIVE SYNTHETIC DIETS INSECTS

Data Coordinates and Footnote	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-44 B	1b	1-44 G	12b,11a	Fn 10,11,12,13	
1-44 C	2a	1-44 H	12c	Fn 13	11b
1-44 D	3c,4a	Fn 2,3,4	b	Fn 14	15b
Fn 1	5a,6a,7a,15a,b	Fn 6		Fn 17	16b
1-44 E	8b	Fn 7	b	Fn 18	17b
1-44 F	9b	Fn 8			

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55. SELECTED SOURCES FOR CERTAIN NUTRIENTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
34 36-39 B	2b	50-54 B	2b	77 B	8b 9b,10b
35 B	2b 3b	55-62 B	6b	80-85 B	8b
40-42 B	1b	63-67 B	7b	All other values and Fn 3,6	1a
43-49 B	4b	74-76 78 79 B	8b,9b		

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56. BALANCED SALT SOLUTIONS FOR ISOLATED ANIMAL TISSUES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,6 9,10,13 B & Fn 8	1d	1,4,6 9,10,12 13 CH & Fn 2,3,6	6d	2,3 5,6 7 9,10,11 13 L & Fn 4,6 7	10de
1 4,6,10 C	2d	1 4,5,6 7 9,10,11 13 I	7bd	1,4 5,6 7 9,10,11 13 M	11bd
1 6 9,10 D & Fn 1	3d	1,4,6 7 9,10,11 13 J	8ed	2 4,6 7 9,10,11 13 N	12d
1,4,6 9,10,12,13 E & Fn 6	4d	1 5,6 9,10,12,13 K	9abed	1 4,6 9,10,11,13 O	13bd
1 4,6,10,12,13 F	5ed				

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57 NUTRIENT SOLUTIONS: HIGHER PLANTS

Data Coordinates and Footnotes	Contributors and References
1-6,8 9,11,13 B	2h
1 5 7,8,10,12,13 C	3e
Fn 1	1g,4d,5f,6i 7a,8a, 9h,10e
Fn 2	b
Fn 3	c

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	1a,4b 5b 12b 14b 17b,18b [20b-30b],32b 33b,34b	19,26,29,30 D	3a	14-17 I	b
		1,3 6,8-11,14 15 17 18,26,27 31		1,8 J	[56a-61a]
Fn 2	35b 39b 41b,42b	E & Fn 7 19	19b	6,9-11,14 17 19, 25,26 J & Fn 13	[56b-61b]
Fn 3	[45b-55b] [62b-67b] [69b-73b]	1,8,26 F	34a	1,7-11,19 26 K & Fn 14	70a 77a,78a
1,3,6,8-11,15,17 18,26 30 B & Fn 4,19	31b	6,9-11,14-17 19 22-25 29 F & Fn 8,20	34b	1,7 10,12 17 19 25,24,26,29 L & Fn 15,16	15a,16a
		3,4 5 8,9 10 G	43a,44a		
1,3 6,8,9-11,15 17 18,21,26,31		18,26 G & Fn 9	43b,44b	1,26 M	36a
		1 H	40a		
C & Fn 5,19	[6a-14b]	6 8-11,19 20,22-24 26,30 H & Fn 10 18	40b	6,8,9 10,12-17 19,24 29 M & Fn 11	36b
1,6,8-10,12,13 28 B & Fn 6	3b			22,25 N	b
14-17 D	b	1,8 I	68a	Fn 17	2a,35b,36b,37a,75a
		6 9-11 19,32 I & Fn 11,12	68b		

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59 CULTURE MEDIA: FUNGI

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
9 10 12,13 17,21 B & F 1	4d	2 4,6,10,14 15,21 24 D	2d	3 7,8,10,14 19,20, 22,24-28 E	b
1 5 7 9,10,11,14 19 23,26 C & Fn 2	3a	5 7-9 11,16 18 19 D & Fn 5 7		Fn 4	1 5

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
4,11,16,21,22 B & Fn 1	3a,4a,5a,6a	1,4 14 16 21,25 26 E & Fn 5	2a	6,15,16,20,25 H & Fn 7	7a,8a,9a
13 16,21,23 26 C & Fn 2	1abc	5 8,12 16,22,26,27 F & Fn 5	2a,12aa	2 5 7,8,10,17 19 29-31 H-O & Fn 8, 9	13
6,11,16,22 25 D & Fn 4 10	2a	1,4,14 16,22,26 G & Fn 5 6	2a	Fn 5	10a,11a

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61. CULTURE MEDIA: CERTAIN BACTERIA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	1a	27,29 30,32 33,35 37 38 41 44-48 53,55,57 58,60 62 E	6b	44 47 55 57 58 G	7
Fn 2	8b	1-4,6 7 9,10 12-15,17,19-24 26,27,29 30 F	4a	56,60 G	7a
Fn 5	10a	31 36 F	4c	62-64,67 G	7
5 7,24,25,27 30 32 36 37 38 40 42,46-49 51 52 54,55,57,58,60 61 B	3a	32 37 39 43-45 47 F	4a	1,2,4 5 7 9,10 12-15,17-24,26 27,29,30,32,33 35,37 38 41, 44-48 52 55 57 58,60,62,67 H & Fn 4	9b
1,2 4,6 7 9,10 12 15,17-25 27 30,32,33 37 39 41,44 46 50 53 55 57 58 62,66,68 C & Fn 7	5a	41 46,48 F	4c	1 5 7 9,10,12 15 17-24,27,29,30 32 33,35 37,38 41,44-48 50 53 55 57,58,60,62 69 I & Fn 9	6a
1,2 4,6 7,9,10 12 15,17-25,27 29,30,32,33,37 38 41 45-48 50 53 55 57 58,60 62,63 D	1a	53,55,57 58,60,62 64,67 F	4a	1-4,6 7,9,10 12-15,17-24,27 29 30 32 34,37 38 41 45-48 50 55 55 59,62,63 65,67 J	2a
1,2 5,6 7 9 10 12 15,17-24 E	8b	1,4,6,8,11 G	7a		
		2,5 5 9,10,12-15 G	7c		
		16,18 G	7a		
		17,19-21 G	7c		
		22-24 G	7a		
		26 G	7c		
		27,29 30,32-35 37 38 G	7a		
		56 41,45 46 G	7c		

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62. CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION INORGANIC FERTILIZERS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and Ref rences
Fa 8-16 18 19,21-26	1a	1,4 5,11 H	1a,2a	24,25,33,36 HI	1a
1 5 7,8,10,11 D	1a,2a	7,17 18,20,21,25 HI	1a,2a	6,13-15,22,24,25	
2 3,4,6 9,12,26-		8 10 32 I	1a,2a	33 I & Fa 17	1a
34 D	1a	2 3 9,12 16,26-31		All other values	Calc. fr 1a
21,25 F	1a,2a	34 H & Fa 20	1a		

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References (1) Ignatieff V (editor) United Nations Food and Agr Organization Agricultural studies 9 1949 (2) McVickar M. H. Using commercial fertilizers Danville Ill.; Interstate Printers and Publishers 1952.

Reviewers: Beer F E.; Clark L. J; Collins G H.; Jacob K. D.; Marshall H. L.; McVickar M. H.; Sauchelli V; Turrentine J W

63 CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION: ORGANIC FERTILIZERS

Data Coordinates and Footnotes	Contributors and References
Fa 8 9	1a
1 5 7 19,22-27	
29 D	1a
6,21 D	1a,2a
1-8 10-22,25,27	
30 HI & Fa 10	
11,12	1a
All other values	Calc. from 1a

Contributor: ( ) McVickar M. H.

References (1) Ignatieff V, (editor) United Nations Food and Agr Organization, Agricultural studies 9 1949 (2) McVickar M. H. Using commercial fertilizers Danville Ill. Interstate Printers and Publishers 1952.

Reviewers: Beer F E.; Clark L. J; Collins G H.; Jacob K. D.; Marshall H. L.; McVickar M. H.; Sauchelli V; Turrentine J W

64 SOIL pH REQUIREMENTS: PLANTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
20,29 36,37,63,66,		2,11 16 30,32 46 C	1 ,a	Fa 1	3
70 B	2b	8 9,12,25,28,31		Fa 2	2b 3
16,40 59 65 78,84,		41 42,45 G		All other values	1a
86 90 B & Fa 4 5	1 ,2b				

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Reviewers Jenny H.; McGeorge W T; Pohlman G G; Thornton H. K.; Walker R. H.; Wherry E. T

65. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fns 2,3	1	30 H	1ae	54 H	4ae
Fn 4	1	31 A-E	1	55 AB	1a
1 2 AB	1a	32 A-E G	1	55 C-E	1
1,2 C-E	1	32 F H	1a	56 AB	1a
3,4 A-E	1a	33 A-E	4a	56 C-G	1
5 A-E	1	34 AB	1a	56,57 H	1a
6 ABC E-H	1a	34 C-E	1	57 AB	1a
6 D	1	35 A-E	1	57 C-G	1
7 8,9 AB	1a	36 C-G	1	58,59,60 A-E	5
7,8,9 C-E	1	36 AB	1a	61 A-E	5a
10 A-E	1	36,37 H	1ae	62 A-D	1a
11 AB	1a	37 AB	1a	62 E-H	1
11 C-E	1	37 C-G	1	63 AB	1a
12 A-C	1a	38 AB	1a	63 C-E	1
12 E	1abcd	38 C-G	1	64 AB	1a
13 AB	1a	38 H	1ae	64 C-E	1
13 C-E	1	39 40 A-H	1	65 AB	1a
14 A-E	1	41 C-E	1	65 C-E	1
15 AB	1a	41 AB	1	66 AB	1a
15 17 C-E	1	42 A-E	2a	66 C-E	1
16 A-E	1	43 A-E	5a,	67 AB	1a
17 AB	1a	44 A,E	5	67 C-F	1
18,19 A-E	1	45 A-E	4a	68 A-E	1
20 AB	1a	46 A-E	2	69 A-F	1a
21,22 A-E	1	47 AB	1a	69 GH	1
23,24 A-E	2	47 C-E	1	70 AB EF	1a
25 A-E	1a	48 A-E	4a	70,71 CD GH	1
26 A-F H	1a	49 A-G	4a	72 A-E	1
26 G	1	49 H	4a	73 AB	1a
27 AB	4ab 5a	50 A-E	2	73 C-E	1
27 C-E	5a	51 AB	1a	74 A-E	1
28 AB H	1a	51 C-G	1	75 A-E	5
28 C-G	1	51 H	1ae	76 A-E	1
29 AB	1a	52 AB	1a	77 C-E	1
29 C-E	1	52 C-E	1	77 AB	1a
30 AB	1a	53 A-E	1	79 A-E	1
30 C-G	1	54 A-G	4a	80 A-E	2a

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66 MINERAL AND VITAMIN COMPOSITION: FOODSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-I	1,3	34-37 B-I	1,2	56-61,66,67 69,70 B-I	1 2
Fn 5-8, 10	3	41-43 B-I	2	68 B	2
7 9 B-I	1,3	44 46 B-I	3	68 C-I	1,2
12,16-18 B-I	1,2	47 B-I	1,2	71 B-I	2
23,24 B-I	3	50 B-I	3	73 B-I	3
25,27,29 31 B-I	1,2	51,52 B-I	1,2	All other values	1
32 B-I	2	53-55 B-I	2		

Data contributed and adapted from (1) Watt B. K. and Merrill, A. L. U S. Dept Agr Handbook 8 1950; (2) Leung, W W Pecot, R. K., and Watt, B. K. U S. Dept Agr Handbook 34, 1952; and (3) Wooster H. A. Jr and Blanck, F.C Nutritional data, Pittsburgh: H. J Heinz Co 1950

Reviewers: Hubbard R F; Bray R. W; Ives M.; Koehakian, C. D.; Shaw R. M.; Watt B. K.; Wooster H. A. J

67 CHEMICAL COMPOSITION OF MILK

Data Coordinates and Footnote	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
6 B-D G-I	2a,3a 4a,5a	33 G	5a	44 B-I	5a
13 B F H J	calc f 1 by	36 B-I G	5a	Fn 5	6a 7a
14 B-G I	calc f 1	43 C E G I K	5a	All others	1
33 B-D G I	5a				

Contributor: ( ) Koehler I M.

References: (1) The composition of milks, Bull of the National Research Council, 254 Jan 1953 (2) Dunson C. V et al J Dairy Sci 35 128, 1952 (3) Miller S., et al J Nutrition 40:499 1950 (4) Miller S and Buttinger V Proc Soc Exp Biol Med 77 96, 1951 (5) Children Fund of Michigan Research Laboratory (unpublished data) (6) Lesher M. Brody J K Williams H H and Macy I G Am. J Dis Children 70:182 1945 (7) Lesher M. et al J Am. Dietetic Assoc 23:211, 1947

Reviewers Black R. J ; Burke B. S.; Henderson L. M.; Koehler I. M.; Stearns G ; Stuart H. C ; Weiss K.

68. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributor and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 3 4 5	7b	50 F	5a 7	41 45 J	1a,2a 3a,5a,6a 7a
Fn 6		5 G	1a,2a 7ab	56 J	1a,2a,3a,6a,7a
98 BC	8	11 13,17 G	1a,2a 3a,6a 7ab	60,69 73 J	1a,2a 5a 6a 7a
4 12 13,15 17,22		12 G	1a,2a,3a 5a,6a,	62 64 75 J	1a,2a,6a,7
23 48,49 53,64			7ab	77 J	1a,3a 4a 6a 7a
76 77-80,83-85		16 G	1a,2a,3a,4a 5a,	91 J	1a,2a,3a,6a,7a
87 91 95 C	7ab		6a,7ab	1-4,6,8,11 13	
2,3,5,19,21,24		20 G	1a,2a,3a 7ab	15-18 K	1a,2a,7ab
26 D	3a 4a,7a	31,42 G	1a,2a,6a 7ab	19 K	2a,7ab
29 31 34 D	3a,7a	37 G	1a,2a 3a,6a 7ab	21,23,24,26,29-32	
32 37 39,42,47,56		43 57 G	1a,2a 3a 7ab	34-36,38 K	1a,2a 7ab
57 59,61,63,67		46 G	2a,3a 7ab	39 K	1a 7ab
68,69 D	3a,4a 7	51,53 56,58,63		41 42 45 47 K	1a,2a 7ab
51,65 72 94 D	3a 7a	66 72 84 G	1a,2a 3a,6a 7ab	45 49,50 K	2a 7ab
90 D	3a 5a 7	62 G	1a,2a,3a 4a 5a	51,53,56-59,61	
13 15,17 E	1a,2a 3a,6a 7ab		6a 7ab	63-65,67-69	
30 E	1a,2a 3a 4a,5a,	88 G	1a,2a,6a 7ab	71 72 76 K	1a,2a 7ab
	6a 7ab	90 94 G	1a,2a 3a,6a,7ab	77 K	1a 7ab
43 E	7ab	98 G	8	78,83-85,87-90,K	1a,2a,7ab
45 E	1a,2a,3a 5a,6a 7ab	2,16 H	1a,2a 3a,6a,7a	80 K	7ab
48 E	2a 3a 7ab	19,23 H	1a,2a,3a 5a 6a,7a	92 K	1a,2a
84 E	1a,2a,3a,6a 7ab	62 H	1a,2a 3a,4a,5a 6a	93 94 K	1a,2a 7ab
92 E	8	65 71 H	1a,2a,3a 6a 7a	1,3,8,12-18 L	2a 7ab
1 F	1a,2a,3a,4a	3 I	1a,2a,6a 7ab	11,19,24,27 L	7ab
3,16,19 F	1a,2a,3a 4a,5a	80 I	7ab	20-22,29-38 L	2a,7ab
	6a 7	3 J	1a,2a,6a 7a	39 56 L	7ab
4 F	1a 2a,3a 5a,6a 7	4 J	1a,2a,3a,6a 7	40,42 43 45-47	
5 6 F	1a,2a 3a 4a,6a 7	5 J	1a,2a 3a,6a,7	49-51 53-55 57	
7 F	3a 6a	11 J	1a 5a 7	63,67-69 71 73	
26 F	1a,2a 3a 4a,5a 7a	19,20,23 J	1a,2a 5a 6a 7a	75 76 L	2a 7ab
32,33 F	1a,2a,3a 4a 5a,	22 J	2a,3a,6a,7a	77,80,81 L	7ab
	6a 7a	26 J	1a,2a 3a 5a,7	78 79,83-90 95 L	2a 7ab
36 F	1a,2a 3a 4a,6a,7	27 34 J	1a,2a,3a,6a 7	98 L	2a
46,62 67 73 F	1a,2a 3a 4a 5a	33 40 J	1a,2a,6a 7a	All other values	7b
	6a,7a				

Contributors ( ) Lucas E. H. (b) Watt B. K. and Merrill A. L.

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Reviewers Abernald J H.; Benedict E. M.; Blanck F C ; Coon. E. J ; Lucas E. H.; Merrill A. L.; Meyer, B. S.; Pratt E. M.; Nestler R B ; Nielsen, J K ; Philpard E. F ; Pigman W ; Sherman, G. B.; Smock R. M.; Somers G. F ; Turner J E.; Watt B. K.; Wolfrom, M. L.; Woessner E. A. J

Data Coordinates and Footnotes	Contributors and References
1-91 93-95 B	8d
92 B	12
2 3 6 14 C	1a,2a,3a,4a 5a 6a 7a 8a
12 13 C	1a 2a 3a 4a 7a,8a
20 C	1a,2a,3a 4a 6a 7a 8a
26 C	2a,3a 6a 7a 8a
27 C	1a 4a 5a 6a 7a 8a
29 C	1a,2a,3a 4a 7a 8a
30-32 C	1a,2a,3a 4a 5a 6a 7a 8a
34 C	1 ,2a,3a 4a 7a 8a
37,41,47 C	1a,2a,3a 4a,5a 6a 7a 8a
43 C	1a,2a 3a,4a 7a 8a
48 C	1a,3a,4a 8a
49 C	1a,3a,4a 7a 8a
56,58 59 C	1a,2a,3a,4a,5a 6a 7a 8a
57 C	1a,2a,5a 8a
65 C	1a,2a,3a 4a 7a 8a
63 67-69 71 72 75 C	1a,2a,3a 4a,5a 6a 7a 8a
80 C	1a 4a,5a 8a
86,89 93 C	1a,2a,3a 4a 5a 6a 7a 8a
91 C	1a,2a,3a,4a 7a 8a
1 D	5aa
2 D	1a 4a,5aa 13a
3 D	1a,4a 5a
4 D	1 ,4a 13a
5 D	1a,5a 13a
6 D	1a,4a,5aa
7 D	5a
8,9,11 15 D	1a,4a
12 D	1a 4a 13a
14 16 D	1 4a,5aa
18-20 D	1a 4a
23 D	1a,4a 13a
21,24,27,31 33 D	1a 4a,5a
24,27,31,32 D	5a
26 D	5ab
29 D	4a
30 D	1a 4a,5a 13a
34 D	1a,4a
35-39 D	1a 4a,5a
36,37,39 D	5a
40 D	1a,5aa
42,44 D	1a 4a,5a
43 D	13a
42,44 47 D	5a
47 D	1a,3a 4a 5a
48-50 D	1a,4a
52 D	5a
55 D	1a 4a,5aa
58-60 D	1a,4a,5a
61 D	1a 4a 5a 13a
57 D	5aa
62 64-66 D	1 ,4a
62 63 65 D	13a
65 D	1a 4a 5a
67 69,71,72 D	1a 4a 5aa
68 D	4a 5a
73 79 80 D	1a 4a
75 78 D	1a 4a 5a
77 80 83 D	13a
83 D	4a
86 88 89 D	1a,4a 5aa
87 D	13a
87 91 D	1a,4a
90 D	5aa
93 D	1a 4a,5a
94 D	1a 4a
3 E	10f
11-13 E	11f
19 E	10f 11f
21,26,31 E	10f
29 E	10f 11f
39 E	10f
47 E	10f 11f
52 55 59 63 69 78 89 E	10f
83 E	10f 11f
87 91 E	11f
93 E	10f
1 F	5aa
2,3 6 F	1a,3a 4a 5a
2,3 6 F	5a
4 F	1 3a 4a
5 F	1 3a,5a 13a
7 F	1a,4a,5a
8 F	3a
9,12 13 15 F	1a,3a 4a
14 F	1a,3a,4a 5aa
16 F	1a,2a,3a 4a,5aa
18-20 23 24 F	1a,3a 4a
21 F	1a,3a 4a,5aa
26 F	3a 5a
27 F	1a,4a,5aa
29 F	3a,4a
30-32 F	1a,3a,4a 5a
31,32 F	5a
33 F	1a,4a 5a
34 F	1a,3a 4a
35 F	1a,3a 4a
36,37,40,42 46 47 F	1a,3a 4a,5aa
39 F	1a 4a 5aa
43 45 49 F	3b
44 F	9b
48 F	3a
50 F	1a,4a
52 56 57 61 F	5a
53 60 F	1a,3a 4a
56-59 61 F	1a,3a 4a,5a
62 F	3a,4a,5a
63 F	1a,3a,4a,5a
64 65 F	1 ,3a 4a
66 F	3b
67-69 71 73 75 F	1a,3a,4a 5a
67-69 71 72 F	5a
77 F	1a 4a
78 F	1a 4a 5a
79 84 87 F	1 ,3a,4a
83 85 F	3a,4a
86 F	1a 4a,5aa
88 89 F	1a,3a 4a,5aa
90 F	3a 4a 5aa
91,94 F	1 ,3a 4a
93 F	1a,3a,4a 5a
4 G	1a 4a
6 G	1a 4a
7 G	4a
20,24,29,30,35,42 68 69 73 77 78, 89 G	1a,4a
26 G	5b
41 51 G	9b
1 76 H	8d
77 H	1a,2a,4a,6a 7a 8ad
78-91 93-95 H	8d
92 H	1a,2a,3a 4a
3 I	1a,2a,4a 5a 6a 7a 8a
4 I	1a,2a,3a 4a 7a 8a
5 I	1a,2a,3a,4a 5a 7a 8a
6 I	1a,2a,3a 4a 5a 6a 7a 8a
8 12 13 15 I	1a,2a,3a,4a 7a 8a
14,16 I	1a,2a,3a 4a 5a 6a 7a 8a
18 19 I	1a,2a,3a 4a 7a 8a
20 I	1a,2a,3a 4a 6a 7a
21 I	1a,2a,3a 4a 5a 6a 7a,8a
23 I	1a,2a,3a,4a 7a 8a
27 I	1a 4a,5a 6a 7a 8a
30,33,35,37 I	1a,2a,3a 4a,5a,6a 7a,8a
34 I	1a 2a 3a,4a 7a,8a
37 I	5a
39 I	1 2a,3a,4a,5a 6a 7a 8a
43 I	1a,3a,4a 7a,8a
45 I	1 ,2a,3a,4a 7a 8a
47 I	1a,2a,3a,4a,5a 6a, 7a 8a
50 I	1a,2a,4a,5a 6a 7a 8a
53 I	1a,2a,3a,4a 7a 8a
56 58,59 63 68 71 72 I	1a,2a,3a 4a 5a,6a, 7a 8a
78 I	1a,2a 4a 5a 6a 7a 8a
80 I	1a 4a,5a 7a,8a
83 I	1a,2a,3a,4a 7a 8a
86 90 I	1a,2a,3a,4a,5a 6a 7a,8a
88 I	1a,2a,3a 4a,5aa 7a 8a
1 7 J	5a
2-6 J	5a 13a
12 15,13,25 J	13a,15b
14 16,21,24 J	5a 13a
18,26 J	5b
27,30-33,39-42,46 J	5a
29 35-37 45 J	13a
47,56,58 J	5a 13a
49 J	3b
50,57,59 60 62,63 J	5a
51,52 J	5ab
53 J	9b
61 65-69 71 J	5a 13a
64,77 J	13a
65 66 J	3b
72 75 86 88-90 J	5a
73 78 80 93 J	5a 13a
83 J	13a
84 85 87 94 J	5b
1 2,4,6 7 9 12 K	1a,4a
5 K	9b
13 14 15 K	1a 4a
16,18,19 K	1a 4a
20,21 K	1a 4a
25,26,27 K	1a 4a
29 K	4a
30 31 32 K	1a 4a
34-37 K	1a,4a
40 K	4a
41 42 45 46 K	1a 4a
47 K	1a
50 53 56-61 K	1a 4a
62 K	4a
63-65,67-69 71 73, 75 77-79 83,84 86-89 91-94 K	1a 4a
85 90 K	4a
1-91,93-95 L	8d
2,3 M	1a,2a,3a 4a,5aa 6a 7a 8a
5 14 M	1a,2a,3a,4a,5a 7a,8a
13 15 19 M	1a,2a,3a 4a 7a,8a
20 M	1 ,2a,3a,4a 6a 7a 8a
21 M	1a,2a,3a,4a,5a 6a 7a 8a
24 M	1a,2a,3a,4a,5aa 6a 7a 8a
26 M	2a,3a,5a 6a 7a 8a
31 33,35,37 41 42 M	1a,2a,3a,4a 5a 6a 7a,8a
31,32,37 42 M	5a
43 M	1a,3a 4a 7a 8a
45 M	1 ,2a,3a,4a 7a 8a
44,47,50 M	1a,2a,3a,4a 5aa 6a 7a 8a
57 M	2a,5aa,8a
59 60-63 M	1a,2a,3a,4a 5a 6a 7a,8a

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
61 N	5a	64-66 N	4a	3 P	1a 4a 5a 13a
65 N	1a,2c,3a 4a 7 ,8a	67-69 71 72 73 N	4a,5ae	7 P	5a
67-69 71 86 89 90 N	1 2c,3c,4a ,5ae 6a 7 8a	75 N	4a,5a	12 15 P	13a
73 75 N	1a 2a,3a 4a 5a,6a 7 8a	73 78,80 N	5a	16 P	1a,4a 5ae 13a
77 N	1 ,2a 4a 7 8a	77 79 83-85 87 N	4a	19 P	1a
80 N	1 ,4a 5a,8c	86,89 90 N	4a 5ae	20 P	1 4a
85,87 N	1a,2a,3a 4a 7a,8a	88 N	5ae 14e	23,26 P	5b
91 N	1a,2a 3a 4a 7a,8a	91 N	4a	21,24,27,31,32 36,39 P	1a 4a,5ae
93 N	1a,2c,3a 4a 5a,6a	92 N	5ae	29 P	13a
97 N	7c,8a	94 N	5a	30 P	1a,4a 5a 13a
94 N	1a,3c,4a 7a 8a	1 3 6 O	4a 5ae	33,35 41 P	1a,4a 5a
1 2 3 6 F	4a 5ae	2 4 8 9 12-15 O	4a	37 P	1a 4a 5ae 13a
4,8 9 F	4a	5 O	4a 5a	40 42 47 50 P	1 ,4a 5ae
F	4a ,5e	7 O	5a	43 P	13a
7 F	5a	16 O	4a 5ae	46 P	1a 4a 5ae 13a
14 16 F	4a 5ae	18-20,22,23 O	4a	52 P	5a
12 13 15 18-20 22,23 F	4a	21 O	5ae	53 P	13a
21 F	5ae	24,27 O	4a 5ae	56 P	1a,4a 5ae
24 F	4a 5ae	26 O	5b	58 P	1 4a 5a 13a
26 F	5b	29 O	4a	61 P	1 4a 5ae 13a
27 30,32 33 F	4a 5a	30,33 O	4a 5a	62 P	1a,4a 5a
29 F	4a	31,32 O	5ae	63 P	1a 4a,5ae
31 F	5ae	34 O	4a	64 P	3b
33 F	5a	35 O	5a	67-69 P	1a 4a 5ae
34 F	4a	36,37,39,40 42, 46 47 50 O	4a,5ae	71 P	1a,4a 5ae 13a
35 41 F	5a	41 O	4a 5c	72 P	1a,4a 5ae
36 37 39 44 46 47 F	4a 5ae	51 53 O	4a	73 75 78 P	1 4a 5a
40 F	5ae	52 56,57 O	5a	80 83 91 P	13a
45 F	4a	56 58 60 O	5a	86 88-90 P	1a,4a 5ae
47 F	5b	57 59 O	4a,5a	87 94 P	5b
50 F	4a 5ae	61 64-69 72 O	4a	93 P	1a,4a,5a
51 53 F	4a	62 63 O	4a,5a	2,3,4 6 12 13 19-21,23 Q	9a
52 F	5a	71 O	5ae	26 Q	9b
56 F	5ae	73 78 O	5a	31-35,37 41,44 47 50 56 61,63,67-69, 72,79 83 85-91 Q	9a
57 F	4a 5ae	75 77 79 83-85 87 91 92 94 O	4a	49 Q	9b
58 60 F	5a	86 89 90 O	4a,5ae	77 Q	5b
59 F	4a 5a	85 O	5ae	78 Q	3b
61 F	4a 5ae	92 O	5a		
62,63 F	4a,5a	93 O	4a 5a		
		1,2,3 6 14 P	1a 4a 5ae		

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Data Coordinates and Footnote	Contributors and References	Data Coordinate and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
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27 B	6aa	36 37 41,42 E	1 ,2a 3a 4a 5a 6a	34 H	1a 4a 6aa
28-43 B	6a	43 E	1a,3a 4a 5a 6a	35-39,41-45 H	6a
44 B	3a 6aa	45 E	1 ,2a,3a 4a 5a 6a 7a	66 H	6aa
47-49 B	6a	46 47 E	1a 2a 3a 4a 5a 6a	67 75 H	6a
50 B	2a,3a 6aa	48 49 E	1a,3a 4a 6a	77 H	4a 6aa
51 91 B	6a	50 E	2a 3a 4a 5a 6a	78-91 93-95 H	6a
92 B	2a 4a	51 E	1a,2a,3a 4a 6a 7a	2 9 I	1a,2a,3a 4a 6a
93-95 B	6a	56 61 65 67 69 E	1a 2a 3a 4a 5a 6a	3-6 I	1a,2a,3a 4a,5a 6a
2,4,5 C	2a 3a,4a 5a 6a	59 63 68 E	1a,2a,3a,4a 5a 6a 7a	12 I	1a,2a,3a,5a 6a
11 18 C	2a,3a,5a 6a	70 E	2a,3a 5a,6a	13 14 I	1a,2a,3a,4a,5a 6a
14 C	2a 3a 4a,5a 6a	71 72 75 E	1a 2a 3a 4a 5a 6a	18 I	1a 4a 6a
26,29 34 C	2a,3a 4a,6a	76 83 E	1a,2a,3a 4a 5a 6a 7a	20 I	2a,3a,4a,5a 6a
30,36 C	2a,3a 4a,5a 6a	79 E	1a,2a,3a 6a	21 23 24 29 I	1 2a,3a 4a 5a 6a
39 C	2a 4a,5a 6a	84 E	1a 3a,4a 6a	32 I	2a,3a 4a,5a 6a
40,43 51 57 C	2a,3a 4a 6a	86 88-91 94 E	1a 2a 3a 4a 5a 6a	31,36 37,41 59 61 63 67 69 I	1a,2a,3a 4a,5a 6a
47 53 56 C	2a,3a 4a 5a 6a	87 E	1a,2a,3a,5a 6a	60 I	1 ,2a,3a,5a 6a
59 C	2a,3a 5a 6a	1 15,17 F	6a	65 68 I	1a,2a,3a,4a 6a
67 70 C	2a,3a 4a 5a 6a	18,20 F	6aa	70 I	2a,3a,4a,5a,6a
68 C	2a,3a 5a 6a	19 21 F	6a	71 83-87 91 94 I	1a,2a,3a,4a,5a 6a
71 C	2a 3a 6a	22 F	6aa	73,79 I	1a,2a,3a,4a 6a
74 C	2a,3a 5a 6a	23-30 F	6a	1-91 J	6a
83 C	2a,3a,4a 6a	31 F	6aa	92 J	2a,4a
84-86 89,94 C	2a,3a,4a 5a 6a	32 F	6a	93-95 J	6a
1-20,23-91 D	6a	34-39 41-46 F	6a	1-4 6 K	1 ,2a,3a,4a,5a 6a
92 D	2a 3a	48-51 F	6aa	12 K	1a,2a,3a,5a 6a
93-95 D	6a	52-57 F	6a	13 K	1a,2a,3a,4a,6a
2,4 8 E	1a,2a 3a 4a,5a 6a 7a	58 64 F	1a,6aa	14 19-21,23 29 K	1a,2a,3a,4a,5a,6a
3,5 6 11 E	1a 2a,3a,4a,5a 6a	59-63 65-67 F	6a	16,33 K	2a,3a,4a,6a
12 E	1a,2a,3a 5a 6a	88 90 93 F	6aa	34 K	1a,2a,4a 6a
14 E	1a,2a,3a 4a 5a,6a	89 91,94 95 F	6a	35,38 K	2a,3a 4a 5a 6a
15 E	6b	2 17 G	1a,2a 6a	37,41,44 K	1a,2a,3a 4a 5a,6a
17 19,20 E	1a,2a,3a 4a 5a 6a,7a	12 19 G	1a,2a,4a 6a	40 K	2a 3a 4a
18 E	1a,2a,3a,5a,6a 7a	13 G	1a 6a	43 49 K	1a,3a 4a,5a,6a
21 E	1a,2a,3a,4a,5a 7a	21,23,29 32 G	1a,2a 6a	48 K	4a 6a
23,29 E	1a,2a,3a 4a,5a, 6a 7a	53 G	1a 6a	50 K	2a,3a 4a,5a 6a
24 E	1a,2a,3a 5a,6a 7a	62 69 G	1a,2a 4a,6a	56,59 61 K	1a,2a,3a 4a 5a 6a
26 E	6b	65 68 73 81 87 G	1a 2a,6a	65 K	1a,2a,3a,5a 6a
30 32 E	1a,2a,3a 4a,3a 6a	91 G	1a 6a	67-69 72 73 75 K	1a,2a,3a 4a,5a 6a
31 E	1a,3a,4a 5a 6a	1 15 17-21 H	6a	81 K	1a,2a 4a,6a
33 E	2a 3a,4a,5a,6a	22,27 H	6aa	83 87,89 90 93 94 K	1a,2a,3a,4a,5a 6a

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71. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES TROPICAL AND SUBTROPICAL FRUITS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	5	13 DE G I M O Q S		27 F H P R T V X	
1,8 9 13 B	1a	U W BB	3b 4a	Z CC	1a
2,3,4 10-12,14,		13 JK	4a	27 DE GHI LM O Q	
16-21,24-31,33		14 DDF HIJ L MO	4a	U W Y BB EE FF	3b 4a
34,37 38 B	2a	15 D F J L N P R		27 JK	4a
5 7,35,36 40 B	Calc fr col. F-K	T V X Z CC EE	1a	28 D F H J L N P	
	& Fn 1	15 E GHI M O S W		R T X	2a
2,3 5 7 13 14 16		Y BB FF	3b,4a	29 D F H J L P R	
20,25,26,28,30	Calc fr col. F-K	15 K	4a	T V X Z EE &	
33-36 40 C	& Fn 1	16 D J L N P R T		F 6	1a
1 D F H J L N P R		V X Z CC EE	1a	29 E G I MNO Q S	
T V X Z CC EE	1a	16 F I M S U FF	3b,4a	U W Y-DD FF	3b 4a
1 G M O Q S U W Y		17 D F H J L N P		29,30 K	4a
BB DD FF	3b 4a	R T V X	2a	30 D F H J L N P	
2 D F H J L N P T		18 D F H J L N P		R V X Z CC	1a
V X Z CC EE	1a	R T X CC	2a	30 E G M O S Y	
2 E G I M O Q R S		19 D F H J L N P R		EE FF	3b,4a
U W Y BB DD FF	3b 4a	T V X Z CC EE	2a	31 D F H L N P R	
3 4 D F H J L N P		19 E G I M O Q W		T V X Z CC EE	3b
R T V X Z CC EE	2a	Y DD FF	3b,4a	32 D F H J L N P	
3 E G I M O Q S U		19 K	4a	R T V X Z CC EE	2a
W Y DD FF	3b 4a	20 D F H J L N P		32 E G I M O Q S	
5 D-I KK P-EE	3b,4a	R T X EE	2a	U W Y DD FF	3b,4a
5 JK	4a	21 D F GHI L N P-FF	3b	32,33 K	4a
6 D F H L N P R T		22 D F H L N P		33 D F H J L N P	
X Z CC EE	3b	T X Z CC EE	3b	T V X Z CC	2a
7 D-I L-V X-FF	3b 4a	23 D F J N P T V		33 E G I M O R S	
7 JK	4a	X Z	2c	Y BB DD EE	3b 4a
8 9 D F H J L N P		23 GH LM O QR W		34,35 D-I L-EE	3b,4a
R T V X Z CC EE	2a	BB CC EE FF	3b 4a	34,35 K	4a
10 D F H J N P R		24 K	4a	36 D F H J L P T	
T V X Z CC EE	2c	24 F J N P R T V		V X Z	2a
10 E G L M O Q U	3b	X EE & Fn 3	2a	36 G MNO QRS U	
11 D F H J L N P		24 DE GHI LM O Q		BB-EE	3b
R T V X Z CC EE	2a	S U W Y-DD FF	3b 4a	37 D F H L N P R	
11 E G I M O S W		25 H J P R T V X	1a	T V X EE	2a
W Y BB DD	3b	25 D-G L-O Q U		37 E G I J O	
12 F J L N P R		W Y-FF	3b,4a	S-DD FF	4a
T V X Z	1a	25 K	4a	38,40 D-I L-FF	3b
12 HH GHI MO Q W		26 D F H J L N P		39 D-S CC-FF	4a
W Y BB-FF	3b	R T V X Z CC EE	1a		
12 K	4a				
13 F H L N P R T V					
X Z CC EE	1a				

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72 RELATIVE PRODUCTION OF NUTRIENTS FOODSTUFFS OF PLANT ORIGIN

Reference: Data contributed by Christensen, R. P. from Christensen, R. P. U. S. Dept. Agr. Tech. Bull. 963 1948

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73 AMINO ACID COMPOSITION CERTAIN PROTEIN FOODS

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References: (1) Adapted from Report on cooperative determinations of the amino acid content, and of the nutritive value of 14 selected protein food sources Bureau of Biological Research, Rutgers University New Brunswick New Jersey 1950

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74 PROXIMATE CHEMICAL COMPOSITION ENERGY VALUES AND DIGESTIBLE NUTRIENTS; FEEDSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 5,6 7	b	8 I M	3e	17 D-I	1b,3e
1 B-I M	1b	9 11 12 B-I M		17 M & Fn 35	1b
2 B-H	2b,3e	& Fn 24	2b	18 B-I M & Fn 37	2b
2 I M	3e	Fn 23	54	2 3,5 8 10 13 14	
3 BC I M	3e	10 B-I M	2b 3e	17 JKL	Calc fr 3 by
3 D-H	2b,3e	13 B-H	1b,3e	Fn 11,21	
4 B-H M & Fn 12	1b	13 I M	3e	F 8 9 10 13-15	
5 B-I	2b,3e	14 B-I M	2b,3e	17,22,26-31	Calc fr 44
5 M	3e	Fn 32	2b	1 18 N	Calc fr Fn 6 by
6 7 B-I M & Fn 18	2b	Fn 33	54	1 18 O & Fn 12,20	
F 16 19	54	15 16 B-I M	1b	25 34,36,38	Calc fr Fn 7 by
8 B-H	2b,3e	17 BC I	3e		

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75 MINERAL AND VITAMIN COMPOSITION FEEDSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-F H-K	2a	8 B-F H JK	1b	14 B-F H-K	2b
2,4 B-F HIJ	2a	9 B-F J	1b	15 B F	b
3 B-F H-K	1b	9 HI K	1a	16 B F K	2a
5 B EF HIJ	2a	10 B EF H JK	1b	16 CDE HIJ	2b
6 B F IJ	2b	11 B-F H-K	1b	17 B-F H-K	2a
6 CDE	2a	12 B EF HIJ	1b	17 CDE	2b
7 B F	b	13 B H-K	b	18 B-F H-K	1b

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76. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-H	1b	25,27 B-H	1b,3a	60 62-64 66,68 69	
2 B-H	1b,3a	25,27 I M	3a	B-I M	1b
2 I M	3a	Fa 30,44	1b	70 71,77 81 B-I M	3a
Fa 8	1b	28 B-I	1b,3a	72 76 78,80 B-I M	2b
3 B-H	1b	28 M	3a	2 6,8 9 14-16	
4 5 B-I M & Fa 14	1b	29,30 B-H	1b,3a	21-30,33,36-39	
6 B-I	1b,3a	Fa 23	1b	41 43 44,50-52	
6 M	Calc fr 3 by	29 I M	3a	57,58 59 61-63	
7 B-I M	2b	30 M	Calc. fr 3 by	65,67,68 70-81 JKL	Calc fr 3 by
8 9 B-H	1b,3a	31 B-I M	1b	F 25	a
8,9 I M	3a	32 B-K KI M & Fa 54	1b	4,5,11,13,20,34	
10-13 B-I M & Fa 23	1b	32 F	b	40 45-47,49 54,	
14 B-I M	3a	33 B-I	1b,3a	56,57,60 64 66	
F 25		33 M	3a	69 JKL	Calc fr 18
15 B-H	1b,3a	34,35 B-I M & Fa 60	1b	F 10-13 16-22	
15 I M	3a	36,37,39 B-H	1b,3a	34-37 40-43,46,	
Fa 26	1b	36,37,39 I M	3a	47,48-53,56-59	
16-20 B-I M & Fa		F 64,68	1b	62-65	Calc fr 44
28,30	b	38 B-I M	3a	2,4-81 B	Calc fr F 4 by
21-23 B-H	1b,3a	40-42,45-54 B-I M	2b	2 4-81 O & Fa 9,15,	
21-23 I M	3a	43 44 55 B-I M	3a	24,27,29,31 33	
Fa 32,38	1b	56-58 B-I M	2b	39 43 55 61,67	
24,26 B-I M	3a	59 61 65 67 B-I M	3a	69	Calc fr Fa 7 by

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77 MINERAL AND VITAMIN COMPOSITION FEEDSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-K	2a	19-22 B-F H-K	2a	53 B F G	1a
3 G	2a	24 B F H-K	3b	54 B D F	1a
3 J	2a	25,27,28 B F H-K	2a	55 B D F	2b
4 5 B-F H-K	2a	26 B-F H JK	3b	56 57 B DEF	1a
4 B F	a	29 B K	2b	58 B-F	1a
6 CDE H-K	3a	29 C-J	2b	59 B F	2b
7 B-F H-K	2a	30 B F	4a	60 B F G	1a
8 EF		30 CDE H-K	4b	61 B-F	2b
8 CDE H-K	3a	31 B-F J	2a	62 B EF G	1a
9 B-F H-K	4b	32 B DEF H-K	2a	63 B F G	1a
9 CDE G	4a	32 C	2b	64 B DEF	1a
10 F		33-39 B-F H-K	2a	64 G	3a
11 H-K	2a	40 H-K	1a	65 B-F	2b
12 B F H J K	4a	41 B F-K	1a	66 B FGH JK	1a
12 CDE I	4b	42 B H-K	1a	67 B-F	2b
12 G	3a	43 B-F I	2b	68 B F	1a
13 B-J	2a	45 B EF K	1a	69 B-F	1a
13 K	4a	46 B-F	1a	72 B-G	1a
14 B F J	3b	46 G	3a	73 74 B FG	1a
15 B-F H-K	2a	47 B EF	1a	75 B-H	1a
16 B D	3a	48 B DEF	1a	76 B F	1a
16 C E F H-K	4b	49 H-K	1a	77 B D F	2b
17 B EF H-K	2a	50 H-G	1a	78 G	1a
18 B-F H-K	2a	51 H-F	1a	79 F	1a
18 G	3a	52 F	1a	80 B EFG	1a

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Data Coordinates and Footnote	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B E G & Fn 2	1b 2b	7 E & F 16	41b	14 B-E G & Fn 30 31	15b 54b
1 F & Fn 3	1b 57b	8 B-E G & Fn 18,19	21b,22b	15 B	6b
1 H	3b	8 F & Fn 20	23b	15 C E & Fn 33	7b
2 H	58a,3b	8 9 H	11b	15 D & Fn 34	8b
3 B-D & Fn 4	1bc 33bc 54bc	9 B	b	15 F & Fn 35	7b,9b 10b
3 E	19b	9 C-F & Fn 21	30b	15 G & Fn 36	b 6b
3 C-E & Fn 5	20abc	10 BC E	42b	15 H	3b 11b
3 EF E & Fn 6	11b	10 D & Fn 22	43b	16 B-D & Fn 37 39	4b
4 B D	b	10 F	44b	16 F	5b
4 C & Fn 7	31b	10 G	55b	16 G & Fn 37 39 41	4b 6b
4 EF	52b	11 B-D G & Fn 24	12b 13b 14b	16 H	5b
5 B-D G & Fn 9	24b	11 EF	b	17 BC	b
5 EF	55b	11 H	3b 11b	17 D G & Fn 42	45b 46b
6 B & Fn 11	55b	12 B-D & Fn 25	17b	17 EF & Fn 43	47b
6 D & Fn 12	56b	12 G	18b	17 GH & Fn 44	48b
6 E	50b 57b 58b	12 H	11b	18-23 B E GH	b
6 F & Fn 13	57b 58b	13 B & Fn 26	20a	18-28 C	b
6 G	18b	13 C & Fn 27	27b	18-22,24 25 B & Fn 45	49b 50b
6 H	57b	13 EF G & Fn 28	59b 60b 61b	23 D	62b
7 B B	55b	14 B D F & Fn 32	15b,16b 54b	23 24 F & Fn 46	55b
7 C FG & Fn 14 15	42b			26 B-H	b

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76. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-M	1b	25 27 B-M	1b,3a	60,62-64 66 68 69	
2 B-M	1b,3a	25,27 I M	3a	B-I M	1b
2 I M	3a	Fn 30 44	1b	70 71 77 81 B-I M	3a
Fn 8	1b	28 B-I	1b 3a	72 76 78,80 B-I M	2b
3 B-M	1b	28 M	3a	2 6,8 9 14-16	
4 5 B-I M & Fn 14	1b	29,30 B-M	1b,3a	21 30 33,36-39	
6 B-I	1b,3a	Fn 23	1b	41 43 44 50-52,	
6 M	Calc fr 3 by	29 I M	3a	55 58,59 61-63,	
7 B-I M	1b	30 M	Calc. f 3 by	65 67 68 70-81 JKL	Calc fr 3 by
8 9 B-M	1b,3a	31 B-I M	1b	Fn 25	
8,9 I M	3a	32 B-M HI M & Fn 54	1b	4,5 11,13,20,34,	
10-13 B-I M & Fn 23	1b	32 F	b	40 45-47,48,54	
14 B-I M	3a	33 B-I	1b,3a	56 57 60,64 66	
F 25		33 M	3a	69 JKL	Cal f 1d
15 B-M	1b,3a	34,35 B-I M & Fn 60	1b	Fn 10-13 14-22,	
15 I M	3a	36 37,39 B-M	1b,3a	34-37,40-43 46	
F 26	1b	36,37,39 I M	3a	47 48-53 56-59	
16-20 B-I M & F		Fn 64 66	1b	62-65	Calc fr 44
26,30	b	38 B-I M	3a	2,4-81 E	Cal fr F 6 by
21-23 B-M	1b,3a	40-42,45-54 B-I M	2b	2 4-81 O & Fn 9,15	
21-23 I M	3a	43 44,55 B-I M	3a	24,27,29,31,33	
Fn 32,36	1b	56-58 B-I M	2b	39 43 55 61 67	
24 26 B-I M	3a	59,61 65 67 B-I M	3a	69	Cal fr Fn 7 by

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77 MINERAL AND VITAMIN COMPOSITION: FEEDSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-K	2a	19-22 B-F H-K	2a	53 B F G	1a
3 G	2a	24 B F H-K	1b	54 B D F	1a
3 J	2a	25,27,28 B F H-K	2a	55 B D F	1b
4 5 B-F H-K	2a	26 B-F H JK	1b	56 57 B DEF	1a
6 B F		29 B E	2b	58 B-F	1a
6 CDE H-K	3a	29 G-J	2a	59 B F	1b
7 B-F H-K	2a	30 B F	4a	60 B F G	1a
8 BF		30 CDE H-K	4b	61 B-F	1b
8 CDE H-K	3a	31 B-F J	2a	62 B EF G	1a
9 B-F H-K	4b	32 B DEF H-K	2a	63 B F G	1a
9 CDE G	4a	32 G	2b	64 B DEF	1a
10 F		33-39 B-F H-K	2a	64 G	3a
11 B-K	2a	40 B-K	1a	65 B-F	1b
12 B F H J K	4a	41 B F-K	1a	66 B FGH JK	1a
12 CDE I	4b	42 B E-K	1a	67 B-F	1b
12 G	3a	43 B-F I	1b	68 B F	1a
13 B-J	2a	45 B EF H	1a	69 B-F	1a
13 K	4a	44 B-F	1a	72 B-G	1a
14 B F J	1b	44 G	3a	73 74 B FG	1a
15 B-F H-K	3a	47 B EF	1a	75 B-H	1a
16 B D	3a	48 B DEF	1a	76 B F	1a
16 C E F H-K	4b	49 B-K	1a	77 B D F	1b
17 B EF H-K	2a	50 B-G	1a	78 G	1a
18 B-F H-K	2a	51 B-F	1a	79 F	1a
18 G	3a	52 F	1a	80 B EFG	1a

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Data Coordinates and Footnote	Contributor and Reference	Data Coordinate and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B E G & Fn 2	1b 2b	7 H & Fn 16	41b	14 B-E G & Fn 30 31	15b 54b
1 F & Fn 3	1b 37b	8 B-E G & Fn 18,19	21b,22b	15 B	6b
1 H	3b	8 F & Fn 20	23b	15 C E & Fn 33	7b
2 H	37a,3b	8 G H	11b	15 D & Fn 34	8b
2 B-G & Fn 4	1bc 37bc 38bc	9 B	b	15 F & Fn 35	7b,9b 10b
3 B	17b	9 C-F & Fn 21	30b	15 G & Fn 36	b 6b
3 C-E & Fn 5	20abc	10 BC E	42b	15 H	3b 11b
3 EF E & Fn 6	11b	10 D & Fn 22	43b	16 B-D & Fn 37 39	4b
4 B D	b	10 F	44b	16 F	5b
4 C & Fn 7	31b	10 G	33b	16 G & Fn 37-39 41	4b 6b
4 EF	32b	11 B-D G & Fn 24	12b,13b 14b	16H	5b
5 B-D G & Fn 9	26b	11 EF	b	17 BC	b
5 EF	27b	11 H	3b 11b	17 D G & Fn 42	45b 46b
6 B & Fn 11	55b	12 B-D & Fn 25	17b	17 EF & Fn 43	47b
6 D & Fn 12	56b	12 G	18b	17 GH & Fn 44	48b
6 E	52b 37b,38b	12 H	11b	18-25 B E GH	b
6 F & Fn 13	37b,38b	13 B & Fn 26	45b	18-22 C	b
6 G	18b	13 C & Fn 27	27b	18-22,24,25 D & Fn 45	49b 50b
6 H	37b	13 DE G & Fn 28	50b 60b 61b	23 D	62b
7 B B	39b	14 B D F & Fn 32	15b 16b 54b	22 24 F & Fn 46	53b
7 C FG & Fn 14 15	40b			26 B-E	b

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Data Coordinates and Footnotes	Contributors and References
1 31 ARCHFORMIX	b
32-41 ARCHFORMIX	2a

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80. APPARENT DIGESTIBILITY AND ABSORBABILITY OF NUTRIENTS: VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 MCD	1a	12,54 E	7a,8a,9b,11b,12a 13b	20 I KL	6g,d
2,3,6 7 9,11 MOD	5i			25 I-L	6,d
4 MCD	2a	12 MH	5i	25,26,27,31 33 38 MCD	5i
5 D	1a,2a	12 54 O	5d	28-30,33,36 MCD	2a
8 B D	2a	13 E-H	6f,d	32 E-L	6,d
10 MCD	2a	13 I L	6,d	37 O	2a
10,11 MOM	6f	13,16,18,19 MOD	5i	41,42 44 E-H	6f
10 I KL	6fg	16 E H	6,d	43 E-H	6f,d
12 MC	1a	17,18,21,22,23, 26 MCD	2a	46 E O	4g,6
12,54 D	1a,2a	18 I-L	6,d	47 MCD	5i
12 E	4a,6f	19 E-H	6a,d	49 I-L	6g,d
12 FD	8b 9b,10b,11b,12b 13b	20 E-H	6,d	Fn 2	3b
				All other values	6

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61 CALORIC VALUES OF NUTRIENTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-H	1f 8f	4 L O	Calc f (1 L O minus 3 L O)	9 B-R	Calc fr (8 B R)
1 B-K	1g,8			10 B-K	Cal f (4 B-K minus 7 B-K)
1 L	4eh 8i	4 MN	Calc fr 1 3 MN		
1 MN	9e	4 P R	10j,11j	10 FG	1f,8f
1 O & Fn 4	9i,17 18	4 Q	Calc by be	10 HI	g
1 PQR	10j 11j	5 B-R	Calc fr (4 B-R and 1 B-R)	10 L-O	Calc fr (4 L-O minus 7 L-O)
3 MN	Calc fr 9				
3 B-G	1f,8f	6 B-G & F 16,17 18		10 PQR	Calc fr (4 PQR minus 7 PQR)
3 H	3d		1b,8b		
3 I	6g	6 HI	Calc fr (5 HI)	11 B-G	Calc. fr (10 B-G & Fn 16,17,18)
3 JK	g	6 L-O & Fn 19	17 18		
3 L & Fn 12	h	Fn 20	h	11 HI	Calc. fr (10 HI & F 21)
3 MNO & Fn 13	17,18	6 P-R	Calc fr (5 P-R)		
3 P R & Fn 14	10j 11j	7 BC & Fn 21	f	11 L-O	Cal fr (10 L-O & Fn 19,20)
3 Q	Calc by b & e fr 10,11 19	7 HI & Fn 22	7g		
		7 L	4e (12 16)i	11 PQR	Calc fr (4 PQR minus 7 PQR)
4 B-G	1f,8c	7 P	e		
4 HI	Calc fr (1 HI 3 HI) by g	8 BC HI L P	Calc fr (4 and 7 BC HI L P)	Fn 6	4e
				Footnote	d

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62 ACCUMULATIVE EFFICIENCY OF FEED UTILIZATION FOR GROWTH: VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-G I	4e,5e	5 B D F	7	9 B-G	
3 B-G	4e 5e	6 B-G & Fn 1,2,3	1b	10 B-I	a
4 B D F	6	7,8 B-G I	a	Fn 2,3 4	Calc fr

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References: (1) Davey R. J U. S. Bureau of Animal Industry unpublished data (contributed by b) (2) Mills C A. Am. J Physiol. 137:305 1942 (contributed by d) (3) Greenman M. J and Duhring F L. Breeding and care of the albino rat Philadelphia: Wistar Institute of Anatomy and Biology 1923 (contributed by d) (4) Green, W W and Hurl J J Animal Sci. 12 561 1953 (5) Ragsdale A C Mo. Agr Exp. Sta. Bull. 336 and 338 1934 (6) Smoothed curve of male gain in weight per gram of feed at different percentages of mature weight calculated from reference 2 (7) Smoothed curve of male gain in weight per gram of feed at different percentages of mature weight calculated from reference 3

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Data Coordinates and Footnotes	Contributors and References
1 51 ASCORBIC ACID	1b
52-41 ASCORBIC ACID	1a

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References: (1) Table of food values recommended for use in Canada, Ottawa: Dept. of Health and Welfare 1951 collected from: Cheldelin, V. H., Woods A. M. and Williams R. J. J Nutrition 26:477 1943; Cooperman, J. M. and Elvehjem C. A. J Am. Dietet. Assoc. 19:155 1943; Delaney R. M., Brodie J. and Willard, A. C., J Canad. Dietet. Assoc. 6:6 1944; Table of vitamin losses in cooking, Washington, D. C. National Research Council, 1944; Cover S. L., McLaren, B. and Cover S. Food Research 8:115 1943; Fett L. R. Canad. J Res. D 20:275 1942; Russell W. C., Taylor M. W. and Beuk, J. F. J. of Nutrition 25:275, 1943; Simpson, J. I. Food Research 8:353 1943; Adams G. and Smith, S. L., U. S. Dept. Agr. Misc. Publ. 556 1944; Van Duyne F. O., Chase J. T. and Simpson, J. I. Food Research 10:72, 1945. (2) Table of food values recommended for use in Canada, Ottawa: Dept. of Health and Welfare 1951 collected from sources in reference (1) plus Cover S., McLaren B. A. and Pearson, P. B. J Nutrition 27:363 1944; Hills M. C., Robinson, A. D. and Levinson, A. J Canad. Dietet. Assoc. 5:85 1943; Jackson, S. H., Crook, A., Malone V. and Drake T. G. H. J Nutrition 29:391, 1945; McIntire J. M., Schweigert B. S. and Elvehjem, C. A. J Nutrition 26:621, 1943; McIntire J. M., Schweigert B. S., Henderson, L. M., and Elvehjem, C. A. J Nutrition 25:143 1943; Schweigert B. S., McIntire J. M. and Elvehjem C. A. J Nutrition 26:65, 1943.

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80. APPARENT DIGESTIBILITY AND ABSORBABILITY OF NUTRIENTS: VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 MCD	1e	12,34 E	7a,8a,9a,11a,12a 13a	20 I EL	6g,4
2 3,6 7 9,11 MCD	51			23 I L	6,4
4 MCD	8e	12 MV	51	25,26,27,31 35 38 MCD	51
5 D	1e,8e	12,34 O	51	28-30,33,36 MCD	8e
6 9 D	8e	13 E-E	6f,4	32 E-L	6,4
10 MCD	8e	13 I-L	6,4	37 C	8e
10,11 MCD	6f	15,16,18,19 MCD	51	41,42 44 E-E	6f
20 I EL	6fg	16 E-E	6,4	43 E-E	6f,4
12 MC	1e	17,15,21,22,25 26 MCD	8e	46 E O	4g,6
12,34 D	1 ,8e	18 I-L	6,4	47 MCD	51
12 E	4e,6f	19 E-E	6e,4	49 I-L	6g,4
12 FS	8h,9h,12h,11h,12h, 13h	20 E-E	6,4	Fa E	3b
				All other values	6

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81 CALORIC VALUES OF NUTRIENTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-O	1f 6r	4 L O	Calc fr (1 L O	9 B-B	Calc fr (8 B B)
1 B-R	1e,5		minus 3 L O)	10 B-R	Calc fr (4 B-R
1 L	4ek 6t	4 MO	Cal fr 1 3 MO		minus 7 B-R)
1 MO	9e	4 P R	10j 11j	10 PJ	1f,6f
1 O & Fn 4	9? 17,18	4 Q	Cal by 4e	10 RI	g
1 PQR	10j 11j	5 B-P	Calc f (4 B-R	10 L-O	Calc. fr (4 L-O
3 MO	Cal fr 9		and 2 B-B)		minus 7 L-O)
3 B-O	1f,6r	6 B-O & Fn 16 17		10 PQR	Calc f (4 PQR
3 R	5e	18	16,2b		minus 7 PQR)
3 I	6q	6 RI	Calc fr (5 RI)	11 B-O	Calc fr (10 B-O
3 JK	g	6 L-O & P 19	17,18		& Fn 16,17,18)
3 L A Fn 12	h	Fn 20	h	11 RI	Calc fr (10 RI &
3 MO & Fn 13	17,18	6 P-R	Calc fr (5 P-R)		Fn 20)
3 P R & Fn 14	10j 11j	7 M & Fn 22	2	12 L-O	Calc fr (10 L-O
3 Q	Calc by 3 &	7 RI & Fn 23	7q		& Fn 17,20)
	fr 10 11 13	7 L	4e (12 16)1	12 PQR	Calc fr (4 PQR
4 B-O	1f,8r	7 P	a		minus 7 PQR)
4 RI	Calc fr (1 RI	8 MO RI L P	Calc fr (4 and 7	Fn 6	4e
	3 RI) by g		MO RI L P)	Bradunote	d

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Reviewers Bird, H R ; Brody S.; Combs G. F ; Conrad, H. R ; Garrigus W P ; Greenberg, L. D ; Hibbs J W ; Kare P K ; Irvin, H. M.; Nellen, W J ; Mitchell H. H ; Moore L. A ; Rinehart J F ; Brannon E W ; Tillman, A. D ; Tucker A. E.; von Wagonen, G.; Watt B K

82 ACCUMULATIVE EFFICIENCY OF FEED UTILIZATION FOR GROWTH: VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-O I	4e 5e	5 B D P	7	9 B-O	
3 B-G	4e,5e	6 B-O & Fn 1,2 3	1h	10 B-I	
4 B D P	6	7,8 B-O I		Fn 2,5 4	Calc. fr

Contributors: (a) Bird H. R. (b) Davey R. (c) Johnson, E. L. (d) Mills C A ( ) Brannon E. W

References: (1) Davey R. J U S Bureau of Animal Industry unpublished data (contributed by b) (2) Mills C. A. Am. J Physiol. 133 525 1941 (contributed by d) (3) Greenman M. J and Duhring, F L. Breeding and care of the albino rat Philadelphia: Wistar Institute of Anatomy and Biology 1923 (contributed by d) (4) Green, W W and Earl J J Animal Sci. 12:561 1953. (5) Ragsdale A. C Mo Agr Exp. Sta. Bull. 336 and 338 1934 (6) Smoothed curve of male gain in weight per gram of feed at different percentages of mature weight calculated from reference 2 (7) Smoothed curve of male gain in weight per gram of feed at different percentages of mature weight calculated from reference 3

Reviewers: Bird, H. R.; Combs G. F ; Davey R. J ; Hauser G F ; Mills C A.; Nestler R. B.; Ruoff L. L.; Kleeorts, C. A.; Brannon, E. W

83 ABSORPTION, RETENTION, EXCRETION OF NORMAL TISSUE CATIONS: MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 D F LI	15a 16a	7 B FO I X	6a 7a,16a	13 [illegible] G I	1a
2 C X G LIX	11a,14a,15a 19a,20a	8 C XFO LI	1 a,15a,16a	14 B XFO LIX	9a,15a 16a
3 B FO LIX	6a,16a,21a	9 D-G JK	3a 9a,12a,16a,23a	15 C FG I K	9a,16a,18a
4 C F LIX	3a 9a,16a,18a 22a	10 C FG I	8a,7a,9a,14a,16a	16 D F	16a
5 C F LI	16a,18a	11 B G LIX	4a,15a,25a	17 B FO LIX	13a,16a,17a,18a
6 D F X	9a,10a,11a,18a	12 B FG LI	14a,25a		

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References: (1) Beck G Mikrochem. ver Mikrochim. Acta 34:62 1948 (2) Bertrand G and Mokragnatz M. Bull Soc. Chim. France 37:954 1925. (3) Culbertson, W. F J Free A. A. and Thompson D. H. Brit. J Nutrition 4 42 1950 (4) Dasewski, T G and Elkinton J R. Pharmacol. Rev 3:141 1951. (5) Fore H H and Morton R. A. Biochem. J 51:600 1952 (6) Good C A. Fox E. and Bonnage E. Proc. Roy Soc. Med. 1105:157 1951. (7) Gualtieri M. D. Lopez de Azevedo J M. and Bel A. G Rev españ. fisiol. 1 65 1951. (8) Hamilton J G, N Eng J Med. 240:863 1950. (9) Heffter A. Handbuch der experimentellen pharmakologie, Berlin: Julius Springer 1923-30 (10) Maynard L. A. and Smith S. E. Ann. Rev Biochem. 16:273 1947 (11) McCance R. A. and Sprey C. M. Clin. Sci 10:113 1951 (12) McClure F J Ann. Rev Biochem. 18:335 1949 (13) Mendel L. B. and Closson, O. E. Am. J Physiol. 16:152 1906 (14) Norris W P and Kisieleski, W, Cold Spring Harb Sym. 13:164 1948 (15) Shohl A. T Mineral metabolism, New York: Reinhold Pub Corp 1939 (16) Sollmann, T A manual of pharmacology, Philadelphia W B Saunders Co 1948 (17) Wallace B L. and Flaherty F G J Clin Invest 26:1125, 1947 (18) Widdowson E M and McCance R. A. Proc Nutrition Soc 1:280, 1944 (19) Bellin, J and Laszlo, D Science 117:331, 1953 (20) Engelmann K Eng-Larsen, B and Walz, O J Physiol. Rev 35:486 1955 (21) Hood, S L. and Comar C L. Arch. Biochem. 45:423 1953 (22) Harp M. J and Scoular F I, J Nutrition 47 67 1952 (23) Brauer W D Parkinson, J D Jr and Rayne, E. L. Fed Proc 12:503, 1953 (24) Bauer G G Am. J Med. Sci 226:80, 1953 (25) Lipsar A. Fisto S B and Freedberg A. G. J Appl Physiol. 5 317 1953

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84 ABSORPTION RETENTION EXCRETION OF FOREIGN CATIONS: MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 D-G I K	29a	15 DEF I	9a,6a,10a,39a	28 C EF I K	6a,21a,31a
2 C E-I K	5a,6a 10a	16 C EFO IJK	7a,10a,24a,30a	29 C I K	20a
3 C FG I K	10a,15a,19a,32a	17 C FG IJK	34a	30 D G	6a
4 C E I K	8a,10a,19a,32a	18 DE G K	9a,10a	31 D F	10a
5 D-G I K	25a,32a,36a,37a	19 DE	6a	32 B F I	16a,17a,38a
6 D-G I K	10a,14a,38a	20 D G I	2a,6a	33 D-G IJ	10a,30a,38a 34a
7 D F I K	10a,21a 34a,35a	21 D-G I K	10a,16a	34 C E I K	6a,21a
8 DEF K	8a,32a	22 EF I K	10a	35 C F EIJ	8a,32a
9 DEF I	33a	23 D-G I K	1a,8a,25a,27a,33a, 40a	36 B FG I K	38a,42a,43a
10 D-G I K	40a			37 DEF I K	6a,26a 24a
11 B G I	28a	24 D-G I K	11a,31a,41a	38 C EF I	3a,32a
12 DEF I K	4a,12a,32a	25 DEF K	8a,10a	39 DEF I K	2a,8a,23a,33a
13 B EFG I K	38a	26 DEF K	8a	40 DE	2a,8a
14 B F I K	32a	27 DE	29a		

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85 ABSORPTION RETENTION EXCRETION OF [illegible] ANTICOAGULANTS MAMMALS

Data Coordinates and Footnotes	Contributor and References	Data Coordinates and Footnotes	Contributor and References	Data Coordinates and Footnotes	Contributors and References
1 B EFG I-L	8a	3 B E J	7 8a 10b	6 C EFG JKL	6a
2 B EFG JKL	7a 8a	4 B FG JK	6a	7 C F J L	5a 4 6a 7
2-4 E	6a	5 C EF JL	2a 4 5a 9a	8 B F J L	1a 5a .a

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References (1) Boyd T C. and De N K Ind J Med Res 20-[illegible] 1933 (2) Comar C L. Singer L. and Davis G K. J Biol Chem. 180-913 1949 (3) Goodman L. and Gilman A. The pharmacological basis of therapeutics New York Macmillan Co 1941. (4) Gwilbessee M D Lopes de Azevedo J M. and Pal A B Rev espan. [illegible] 1951 (5) Heffter A. Handbuch der experimentellen pharmakologie Berlin: Julius Springer 1932-50 (6) [illegible] P K Tate D M. and Tomlin D. E. Biochem. J [illegible] 1951 (7) Lecoq A. T Mineral metabolism New York Reinhold Publ. Corp. 1949 (8) Sollmann T A manual of pharmacology Philadelphia W B. Saunders Co 1948 (9) Ter Meulen H. Rec Trav Chim. Pays-Bas 20:491 1901 (10) Meckle W Scott E. W and Largent E. J J Ind. Hyg. and Toxicol. 24 199 1942

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86 ABSORPTION RETENTION EXCRETION OF FOREIGN ANTICOAGULANTS MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinate and Footnotes	Contributors and References
1 B FG LJK	3a	3 B C LJK	3a	5 B FG LJK	a
1 5 K	4b	4 D F I	2a	6 C EF I	1a,3a
2 B F I K	1a 3a				

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Reviewers: Cartwright G. D ; Downs A. L.; Finch C A.; Hodge H. C ; Leblond C. P ; McChesney E. W ; Morris V P ; Orten, J M.; Sarett H. P ; Sendroy J J ; Smith F A.; Spiegl C J ; Stannard J N.; Walker B S.

87 CHEMICAL ELEMENTS FUNCTIONS ANIMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-4 B	1a,2a	74-84 B	14a 15a	119-121 E	4a,21a
1-9 C	1a,2a	74-82 C	14a,15a	137 144 B	.a,6a,22a
1,8 E	3a	74-76 D	14a,15a	137 140 C	.a 6a,22a
10-17 B	4a	74 75 E	14a,15a	137,138 D	5a,6a,22a
10-20 C	4a	85-90 B	16a	137 143 E	5a,6a,22a
10-16 D	4a	85-87 C	16a	145-158 B	23a
10-13 E	4a	88-90 C	17	145-149 C	24a
21 B	5a,6a	85-88 B	1.a	145-147 D	25a
21-29 C	5a,6a	89-91 D	16a	145-148 E	25a
21-27 D	5a,6a	85-99 E	16a	155-165 B	5a,6a
21-25 E	5a,6a	100-105 B	4a	155-161 CD	5a,6a
30-32 B	7	100-109 C	4a	155-160 E	5a,6a
30-33 C	7a	100-108 D	4a	166-170 BC	25a
30-37 D	8a	105-105 D	9a	166-174 D	25a
38,39 D	9a	100,101 E	4a	166-171 E	25a
30,31 E	7	106-110 B	19a	175,176 B	26a
40-44 B	10a	106-112 C	19a	175-177 C	26a
40-54 C	11a	106-109 D	9a	175-178 D	26a
40-69 D	10a	110-118 D	20a	175,176 E	27
40-57 E	10a	106-109 E	19a	179-183 BC	28a
70-75 B D	12a	119-126 B	4a,21a	179-186 D	28a
70-73 C	13a	119-136 C	4a,21a	179,180 E	28a
70 71 E	12a	119-131 D	4a,21a		

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(Continued on the next page)

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88. TRACE ELEMENTS FUNCTION ANIMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	10a,11b	16-18 G	20d	57-63 E	67a
2 3 B	14b	19-21 G	21d	64-69 E	69ad
1 2 C	11a,14e,d	29 30 C	40a	50-53 F	70a
3-6 C	3a,14e	31 34 C	39d,41d,43d	54-56 F	78a
7,8 C	12a,14e	29-38 E	37a,38a 42a,43a	50 51 G	66a
1-4 D	8a,14e		46a 47a,48a,49a	52-55 G	67d
5-7 D	6e 7a,14e	39 E	50a	70-74 C	92a
8-10 D	1a,3a,14e	29-38 F	51a	75-76 C	91a
1-4 E	2a 9a,13a,14e	29-31 G	44a	77 78 C	81a
5 E	4a,14e	32-35 G	40aa	79-81 C	87a,88e
6-8 E	14e	40 B	68a	82,83 C	85a,86e
1 3 F	5a,14e	41 B	60a	84,85 C	94e
1 3 G	4a,14e	42 B	54b 57b	86-88 C	80a
11 B	25a,14e	43 B	57a,61a	70-83 D	82a,84e,89a 93e,97e
12 B	29a 14e	44 B	59a,61b,116b	70-76 E	79a
13,14 B	25a,14e	45 46 B	117b,118b	77 E	83ae
15,16 B	36a,14e	41-46 B	65a	70 71 F	90e
17 B	29a,14e	47-49 C	56a	89 B	101a
18 B	14e,24a	41-44 D	63a,64a	90 B	110a
11 13 C	35a,14e	41 42 E	65a	91 92 B	111a
14-16 C	22a,30a,32a,14e	43-49 E	55a	93 B	112a
17,18 C	27a,28a,14e	41-43 F	[illegible]	94 B	108a
19 C	15a,14e	44-46 F	53a	96 B	113e
20 C	34a,14e	50 B	71a 72a	89-103 C	99a,103e,104e
11 16 D	18a,14e	51 B	73a	104-106 C	112a
17,18 D	14e	52 B		107,108 C	100a
19 D	18a,19a,14e	53 54 B	73a	89-92 D	96a
20,21 D	19a,14e	55 B	77	93 D	106a
22-25 D	18a,14e	56 B	68a	94 95 D	97a
26-28 D	33a,14e	57 B	65ae	96-101 D	109a
11 13 E	31a,14e	50 51 C	76a	89 90 E	98d
11,12 F	17a,14e	52 C	74a	91 E	105a
13,14 F	16a,14e	53,54 C	77	89 90 F	107a
15-21 F	14e	50-59 D	70a	89 90 G	108a
11 13 G	14e	50-56 E	66a		

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Vitamin and Column	References
Vitamin A	
Col. A & Ba	1,11,13,14,17 19 20,27 34,37 39,43 44,47 49 53,56,61, 67 68,73,74,78,83, 84 86,90,92,95
Col. B	21,30,50,69 72
Col. C	21,50
Ascorbic acid	
Col. A & Ba	21,50 51,53,40,50, 58,64 68,72
Col. B	31,53 40,58,64 68
Col. C	64 68
Biotin	
Col. A & Ba	50,51 68,72,87
Col. B	3,21,50 68,72
Choline	
Col. A & Ba	3,22,31,28,50,37 68,72,87 and contributed by n, o,r t,v
Col. B	7,22,50,68,72,92
Col. C	21,50,72
Cobalamin	
Col. A & Ba	3,13,21,30,50,66, 72
Col. B	21,30,50,66,72
Col. C	21,50
Vitamin D	
Col. A & Ba	3,21,50,68,72, and contributed by h,k, n,

Vitamin and Column	References
Vitamin D (concluded)	
Col. B	3,21,30,50,68,72
Col. C	3
Vitamin E	
Col. A & Ba	3,4 9,21,30,58,68 72
Col. B	3 4 21,50,58,68,72
Folic acid	
Col. A & Ba	3,6,13,21,50,45,66 72,87
Col. B	3,21,50,45,50 66, 68,72,87
Col. C	66,87
Inositol	
Col. A & Ba	50,85 87
Col. B	21,37 50 68,72
Para-aminobenzoic acid	
Col. A & Ba	13
Vitamin K	
Col. A & Ba	2,3,16,24,25,26,30, 60,68,72
Col. B	2,3,16,24 25,26,60
Col. C	16,68
Niacin	
Col. A & Ba	12,21,29 50 41,50 68,70,72
Col. B	13,21,30,33,41,50, 68

Vitamin and Column	References
Niacin (concluded)	
Col. C	50,41
Pantothenic acid	
Col. A & Ba	3 52 68,72
Col. B	13,21,50 50,66 68
Col. C	66
Pyridoxine	
Col. A & Ba	6,8,10,18, 6 55 57 59 62,65,71, 73,76,77 80 81 88,89,91
Col. B	3,21,50,62 66,68, 72
Col. C	66
Riboflavin	
Col. A & Ba	13,21,50 57 68,72
Col. B	21,30,37 68,72 76 77 79 92 and contributed by h,k,n, w
Col. C	50,68,79
Thiamine	
Col. A & Ba	21,30,57 54,62,68 72
Col. B	21,30,33 57 68,72
Col. C	56,50
Essential fatty acids	
Col. A & Ba	3,15,55,57,68,72
Col. B	15,55,57,48,50 68,72
Col. C	50

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Reviewers The panel of contributors for this table also served as reviewers

90 NUTRIENT DEFICIENCY EFFECTS ON REPRODUCTION MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnote	Contributors and References
1 A & Fn 2	82a,50a 67a,75a 94a 107 120a	4 I MOP	70a 71a 101a,107a 152b	11 J OPQ & Fn 3	85a,87b
1 B	75a	4 J	125b	12 MC GH	16a,19a,118a
1 C	1a,69a,82a,94a 105a 106a	4 K	70a,111a,b	12 F	16b,118b
1 DF	40a 44a,110a 126a	4 L	70a 111a	12 N	116a,117
1 GH	11a,28a 31a,33a, 35a,50a 56a,62a 67a,65a 91a 96a 100a,107a,120a	4 N	43a 44a,45a 79a 119a,121a,136a 151b	12 P	118a,b
1 J L M P	5a,6a,50a 52a 55a	5 MO K	65a,88a,127b	13 A & Fn 8	22a,31a,32a,67 78a
1 O	6a	5 GH	127b	13 MC	78a
1 A & Fn 8	37b 98a	5 OPQ	54a 146b	13 GH	16a,20a 31a,32a 92a,104a
2 B	98a	6 MC GH	85a 84a 46a,57a	13 L MOPQ	137b
2 A & Fn 3	41a 97b 98a	6 M-Q	85a 57b,150b	14 O	8a
2 GH J L MP & Fn 5	4ab 17a,51ab 52ab 41ab,61b 95ab 97b 98a	7 A & Fn 3	72a,73b	14 N Q	8b
2 Q	99a	7 CDE	68a,69a,137b,140b	15 N	7a,86a
3 A & Fn 8	40a 127b	7 N	130b 136b	16 MN	63a
3 B D	14a 35b 40a	7 OP & Fn 7	139b,140b,144b	17 C E	18a,89a,107a
3 F	14a,127b	8 M	56a,64a,112a 141b 143b,149b	17 FG J	12b 53a,106a,115a
3 K B	15a,39 46a,60a 64a,71a 94a	8 N	84b	17 L	21b,103b
3 Q	94a	8 OP & Fn 3	84b,86a,112a,113a	17 M	21a,107b
4 B	39a 56a,66a 77a, 81a,128a,125a, 134a	8 Q	151a 156b,157b	18 FG L	87a
4 DK	49a,65a,69a 114a,125a 134a	9 MO	152b	18 N	a
		9 P	80a	19 DF J	99b,127b
		10 A & Fn 2	56a	20 DF J	90a,142b
		10 MC K	80a,89a	21 C E	47 48a 49a,108a
		10 GH	89a 56a,125a	22 C	70a
		10 J OP & Fn 3	133b	Fn 12	72a
		10 N	9a,10a	23 MC & Fn 13	74a,133b,134b
		11 MC K	88a,134b	24 CD	1a,2a 3a,95a
		11 GH	89a	24 OP	3b
				Fn 13	154b
				Fn 4	139b,145b,147b,148b

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Reviewers: Erdhoff R. K.; Fallis B. D. Jr ; Hertz R.; Nelson, M. M.; Warkany J ; Wolbach S. B.

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
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5 5 C	7b	[illegible] 31 33 BC	[illegible] 11b	1 2 BC	[illegible]
6 7 BC	[illegible]	26 27 BC	[illegible]	5	[illegible]
8-10 BC	[illegible]		11b a	[illegible]	[illegible]
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		36 BC	[illegible] 11b	1 BC	[illegible]
14 B	[illegible]	[illegible] BC	[illegible]	[illegible] 5	[illegible] 11b
15-17 BC	[illegible]	37 [illegible] BC	[illegible]	7	b
18-20 BC	[illegible] 11b,a	40 C	8		
		41 B	[illegible]		

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92 SIGNS OF CHEMICAL ELEMENT DEFICIENCY AND EXCESS: HIGHER PLANTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
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1 C	1a,2a 3a,4 5a, ,h	5 C		Fe 2	1f
2 B	1a,2a 3a,4a 5a e	6 B	1a,2a 3a,4a,5a	9 C	,h
2 C	1a,2a 3a,4a 5a e	6 C	1a,2a 3a,4 5a b	10 B	1a,2a,3a 4a 5a b
Fe 1		7 B	1a,2a 3a 4a ,a	10 C	1a,2a 3a 4a,a
3 B	1a,2a 3a 4 5a	7 C	11g	11 BC	1a 2a 3a 4a,5a
3 C	7a 8g 9a 10g b	8 B	1ad,2a 3a 4 5a b,e	12 B	1a 2a 3a 4a,5a 12i
4 BC	1a,2a 3a 4a 5a	8 C	1a,2a 3a 4a 5a,a	12 C	6f g 9f [illegible]
				Fe 3	1

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	9,59b, j	5 B		9 B	18a,i
1 C	5,18a,	5 C	18,54	9 C	18,54
1 D	8,54,[illegible]a,g	5 D	18,54	9 D	54
1 E	18d,68a,54d	5 E	18b	9 E	18db,54d,68a
1 F	18,57,42 43	5 F	17,18,23	9 F	18b 54
1 G	18,27,a	5 G	55	9 G	55 e,g
1 H	18d,23,31,32 33,35, 47,54d,a,	5 H	18d,26,30 31,33 35 54d	9 H	18d,23,31,33 36 38,54d
1 I	14,18,20,21,41,	5 I	14 18,54,69a	9 I	14 18 26
2 C	18,55,a	6 B	60af	10 B	12 i,j
2 D	50 54,a	6 C	54	10 C	18 52 55 54
2 E	18db,54d	6 D	61a,69f	10 D	50 g
2 F	18	6 E	18db,54d	10 E	18db,54d
2 G	55 ,9a	6 F	65a,f i	10 F	10a,12,18 54
2 H	18d,26,30 31,33 54d	6 G	55	10 G	55
2 I	18,39,55	6 H	18d,33,35 47 54d	10 H	1,12,18d,26,31,35 34,36,54d,
3 B	44	6 I	18,46		
3 C	11	7 B	15a	10 I	12,14 18,28 40
3 D	19	7 D	68a	11 B	45 j
3 E	7 18db,54d,	7 E	67a	11 C	1
3 F	70a	7 G; H	64a; 71a 71a	11 D	
3 G	15,18,	7 I	8a	11 E	18b
3 H	18,55,	8 B	19	11 F	f,1
3 I	18,49	8 C	18,52 55,54	11 H	18,31,35
4 B	18,j	8 D	54	11 I	14 18
4 C	54	8 E	18b	12 B	66f
4 D		8 F	18b,i,j	12 C	18
4 E	18a	8 G	55	12 E	18db,54d
4 F	41	8 H	16,18d,23,31,33 36 54d,	12 F	4,5 6 57b f
4 H	18,31,35			12 H	18d,35 54d
4 I	18	8 I	14,18,24	12 I	18

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94 CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT DEFICIENCY

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fa 1	a	16,17 BC	17d	29 30 D	6d
1 BC E & Fa 3	1d	F 6	b	29-31 E	5d,6d 19d
2 BC	2d	16-18 D	6d 18d	32 BC	
2-6 DE	2d,3d,4d,5d,6d	16-18 E	5d,6d 19d	32 33 D	6d
7 BC; Fa 4	7d;8d	19 B;19-21 CD	a;6d,9d	32-34 E	5d,6d 14d
Fa 5		19 E	5d,6d,7d 14d,20d	35 BC	
7 D	6d	22 23 BCD	21d	35 DE	6d,26d
7 8 E	6d,9d	22,23 E	5d 6d 15d,21d	Fa 7	a
9 10 DE	4 10	24 BC	22d	36 B;36-38 CDE	;6d,19d,27d
11 BC		25 D	22d 23d	39 B	
11,12 D	11d,12d	24-26 E	4d,5d,25d 24d	39,40 CD	26d
11 13 E	4d 6d 11d,13d 14d,15d	27 B;27,28 CD	;6d	39-42 E	3d,5d 6d,12d,13d, 15d,28d 29d
14 15 CDE	4d 16d	27 28 E	5d 6d,23d		
		29 30 BC	25d		

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95 CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT EXCESS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fa 1		10 DE	15c,16a	16 E & Fa 4	12a 13a,14a
1 BC	1a	11 B-E	4a 8a,9a	18 B	b
1,2 DE	2a 3a	12 B;12 DE	d,4a 10c	18,19 D	16a,17a
3 4 CDE	4a 5a	13 BC	1a	18,19 E	13a,17ba
Fa 3		13-15 DE	3c,11a d	20-25 DE	18c,19a
5 B;5 6 DE	4;6a 7a	16 BC	12a,13a	24 B	
7 10 B		16 17 D	13a	24 DE	15a,16c,20a
7-9 DE	15a,16a				

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BC	1a	30 BD	19a	56 BD	34a
2 BC	2a	31 BD	20a	57 BC	35a
4 BC	3a	32 BC	21a	58 BD	36a
7 BC	4a,5a	33 BD	22a	60 BC	15a
9 BD	6a	35 BD	1a	62 BD	31a
10 BC	7	36 BC	23a	63 BD	37
12 BD	8a	37 BD	24a	64 BD	38a
14 BC	9a	38 BD	25a	65 BC	39a
15 BD	10a	39 BD	1a	66 BD	40a
16 BC	11a	40 BC	26a	68 72 BD	41a
17 BD	12a	41 BC	27a	74 BD	42a
19 BD	13a	42 BD	28a	76 BD	43a
21 BC	14a	43 BD	29a	78,80 BD	44a
22 BD	15a	44 46 BD	30a	82 BD	45a
23 BC	16a	48 BD	31a	85,87 BD	46a
24 BD	17a	49 BD	17a	89 BD	47a
25 BC	18a	50 BC	32a	91 93 BD	48a
27 BD	19a	52 BD	33a	94 96 BD	49a
28 BD	20a	54 BD	4a	97 BD	50a

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97 CHEMICAL CHANGES IN PROTEIN DIGESTION AND ABSORPTION: MAMMALS

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98 CHEMICAL CHANGES IN CARBOHYDRATE DIGESTION AND ABSORPTION MAMMALS

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99 CHEMICAL CHANGES IN LIPID DIGESTION AND ABSORPTION MAMMALS

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100. PATHWAYS OF AMINO ACID METABOLISM

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101. PATHWAYS OF PURINE AND PYRIMIDINE NUCLEOTIDE METABOLISM

Reactions and Footnotes	References	Reactions and Footnotes	References	Reactions and Footnotes	References
Nucleotides —A→ Nucleosides	19,29 32,42,43 48,51,54	Guanosine —H→ Xanthosine	17,26 32 50	Urea —O→ CO_2 + NH_3	28
Adenylic Acid —B→ Inosinic Acid	11,46,52	Guanine —I→ Xanthine	15,16,17 30 33 43 50	Uracil —P→ β-alanine	56 57
Adenosine —C→ Inosine	8,11,17,32,46 55	Pyrimidine nucleosides —J→ Bases	13 58	Footnotes 1,2 3 4	General References
Adenine —D→ Hypoxanthine	3,15,16 18	Cytidine —K→ Uridine	47 53	Footnote 5	10
Purine Nucleosides —E→ Bases	20,21,22 23,24,34 36,37 39,43 49	Cytosine —L→ Uracil	10 27 41	Footnote 6	28,56 57 58
Hypoxanthine —F→ Xanthine	1,3,4 6,7 12 14 25,31,35,40,43 45	Uracil —M→ Barbituric Acid	28	Footnote 7	28
Guanylic Acid —G→ Xanthylic Acid	47	Barbituric Acid —N→ Malonic Acid Urea	28	Footnote 8	56 57
				Footnote 9	1,2 3 4 6 7,12,14 25,31,35 40,43 45 47 and General References
				Footnote 10	2

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1 ID	1a	30 ID	19a	56 ID	34a
2 ID	2a	31 ID	20a	57 ID	35a
4 IC	3a	32 IC	21a	58 ID	36a
7 ID	4a,5a	33 IC	22a	60 ID	15a
9 IC	6a	35 ID	1a	62 IC	31a
10 IC	7a	36 ID	23a	63 IC	37a
12 IC	8a	37 ID	24a	64 ID	38a
14 IC	9a	38 ID	25a	65 ID	39a
15 IC	10a	39 IC	1a	66 IC	40a
16 IC	11a	40 ID	26a	68 72 IC	41a
17 ID	12a	41 ID	27a	74 ID	42a
19 ID	13a	42 ID	28a	76 ID	43a
21 IC	14a	43 ID	29a	78,80 IC	44a
22 ID	15a	44,46 ID	30a	82 ID	45a
23 IC	16a	48 IC	31a	85,87 ID	46a
24 IC	17a	49 ID	17a	89 ID	47
25 IC	18a	50 ID	32a	91,93 ID	48a
27 IC	19a	52 ID	33a	94 96 ID	49a
28 IC	18a	54 ID	34a	97 ID	50a

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97 CHEMICAL CHANGES IN PROTEIN DIGESTION AND ABSORPTION: MAMMALS

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Reviewers Davenport H. W ; Fraser A. C ; Hollander F ; Ivy A. C.; Kleiner I. S.; Kerlin, I. S.; Schatz, E.; Ware K.M.

98 CHEMICAL CHANGES IN CARBOHYDRATE DIGESTION AND ABSORPTION MAMMALS

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99 CHEMICAL CHANGES IN LIPID DIGESTION AND ABSORPTION MAMMALS

Contributors: ( ) Fraser A. C ; (b) Ivy A. C (c) Kleiner I S

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100 PATHWAYS OF AMINO ACID METABOLISM

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101. PATHWAYS OF PURINE AND PYRIMIDINE NUCLEOTIDE METABOLISM

Reactions and Footnotes	References	Reactions and Footnotes	References	Reactions and Footnotes	References
Nucleotides —A→ Nucleosides	19,29 32 42 43, 46 51,54	Guanosine —H→ Xanthosine	17 26,32 50	Urea —O→ CO_2 + NH_3	28
Adenylic Acid —B→ Inosinic Acid	11,46,58	Guanine —I→ Xanthine	15,16,17 30 33,43 50	Uracil —P→ β-alanine	56,57
Adenosine —C→ Inosine	8,11,17 32,46,55	Pyrimidine nucleosides —J→ Bases	13 38	Footnotes 1,2 3 4	General References
Adenine —D→ Hypoxanthine	5,15,16,18	Cytidine —K→ Uridine	47 53	Footnote 5	10
Purine Nucleosides —E→ Bases	20,21,22,23,24,36 56,57 59,43,49	Cytosine —L→ Uracil	10 27 41	Footnote 6	28,56 57 58
Hypoxanthine —F→ Xanthine	1,3,4,6,7 12,14 25,31,35,40 43 45	Uracil —M→ Barbituric Acid	28	Footnote 7	28
Guanylic Acid —G→ Xanthylic Acid	47	Barbituric Acid —N→ Malonic Acid Urea	28	Footnote 8	56,57
				Footnote 9	1,2,3 4 6 7,12,14 25 31,33,40,43 45,47 and General References
				Footnote 10	2

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102. PATHWAYS OF NUCLEOPROTEIN CATABOLISM

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103. PATHWAYS OF CARBOHYDRATE METABOLISM: GLYCOLYSIS

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104. PATHWAYS OF LIPID METABOLISM: MAMMALS

Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References
Triglycerides → Di- and Mono-glycerides	1a,17ba,13d,69b	Di- and Mono-glycerides → Glycerol	6a	Phospholipid → Glycerophosphate	76f 77f 78f 79f,80f
Triglycerides ← Di- and Mono-glycerides	8a 3a,4a,5a 75b	Di- and Mono-glycerides ← Glycerol	8a 3a,4a,5a	Phospholipid ← Fatty Acid; Modified Fatty Acid	8a,9a,10a,11a
Di- and Mono-glycerides → Fatty Acid; Modified Fatty Acid	6a	Fatty Acid; Modified Fatty Acid → Cholesteryl Esters	6a,50b 71b	Pyruvate → Acetyl ~CoA	11a
Di- and Mono-glycerides ← Fatty Acid; Modified Fatty Acid	8a 3a,4a,5a,17b 69b	Phospholipid → Fatty Acid; Modified Fatty Acid	7a	Fatty Acid; Modified Fatty Acid → Fatty Acid~CoA	15a 74a
		Phospholipid → α- β- Glycerophosphoryl-choline	7a	Fatty Acid ~CoA ← Acetyl ~CoA	15a,74b
				Fatty Acid ~CoA → Acetyl~CoA	16a,74b

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Acetyl~CoA → Acetoacetate	16a 18a 19a, 74b	Pyruvate → Lactate	64a 65a	β-OH Butyrate	54a
Acetyl~CoA ← Acetoacetate	17a, 74b	Pyruvate ← Lactate	66a	Fn 17	15a
Acetyl~CoA → Krebs Cycle	20a 21a	Ketogenic Amino Acid and Glycogenic Amino Acid, F 1	46a 47a	Fn 18	43a, 81d 82d, 83d 84d
Acetyl~CoA → Cholesterol	22a 23a, 24a	Triglycerides Fn 3	27a, 28a	Fn 19	49a 50a
Acetoacetate → ? Cholesterol	25a, 26a	Fn 4	63a	Fn 20	51a
Cholesterol → Cholesteryl Esters	29a, 30a, 31a 32a, 72b	Fn 8	33a	Fn 21	55a
Pyruvate → Krebs Cycle	38a	Fn 9	34a 36a 70a	Fn 22	
Fatty Acid ~CoA → Fatty Acid; Modified Fatty Acid	49a, 50a	F 12	35a 36a 37a 73b	Fn 24	44ce, 45ae
		Fn 13	42a	Fn 26	55a 56a, 57a
		Fn 14	39a	Fn 27	48e, 85d, 86d 87d 88d
		Fn 15	40a, 41a	Fn 28	58a
		Acetoacetate Fn 16	52a 53a	Fn 34	60a
				Fn 35	61a
				Fn 36	62a 63a

Diagram adapted from data and diagram contributed by Bloor W R and Stadie W C with modifications by reviewers. Pinpoint bibliography does not list all available references for reactions and footnotes in diagram, but only pertinent references contributed by (a) Artom, C (b) Bloor W R. (c) Fleck E V (d) Garin, G. (e) Van Bruggen, J T (f) Weinman, E O

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104. PATHWAYS OF LIPID METABOLISM: MAMMALS (Concluded)

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105. METABOLIC INTERRELATIONSHIPS: CARBOHYDRATE FAT AND PROTEIN

Diagram adapted from diagrams contributed by (a) Bonner J F; (b) Colowick, S. P; ( ) Saltman, P; (d) Van Bruggen, J T; ( ) Villee C A.

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106. THE KREBS CYCLE

Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References
Aspartate ⇄		Aconitase reaction	6	Fn 5	h
Oxalacetate	1	Oxalosuccinate ⟶		Fn 9	5
Glutamate ⇄		α-Ketoglutarate	7	Fn 11	f
α-Ketoglutarate	1	α-Ketoglutarate ⟶		Fn 17	b
Pyruvate ⟶		Succinate	8	Fn 19	d f,10
Acetyl CoA	2	Succinate ⟶		Fn 20	f
Oxalacetate		Fumarate	9		
Acetyl CoA ⟶		Fumarate ⟶			
Citrate	3	Malate	6		

The diagram, in general, has been drawn up from schemata and comments supplied by all contributors and adapted from general references 11-22

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107 ACTIVITY METABOLISM: MUSCLE

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108 THE CYTOCHROME SYSTEM: MAMMALS

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109. PATHWAYS OF IRON METABOLISM: MAMMALS

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110 PATHWAYS OF CHLOROPHYLL SYNTHESIS

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Reviewers Aronoff S ; Goodwin, T W ; Granick, S ; Porter J W ; Shemin, D.; Wittenberg, J B.

111. THE NITROGEN CYCLE IN NATURE

References: Diagram adapted from Bonner J F Plant biochemistry, New York: Academic Press 1950, contributed by Bonner J F

Reviewers Bonner J F

Data Coordinates and Footnotes	Contributors and References
1 F J N B	1 1f
1 F	30eg
1 B O Q T A Fn 2	1be
Fn 1 for 1,3 A-T	1bde
2 E-K	1be
3 F H N P S	1be 2,2f
3 J	1
Fn 2 for 3 A-T	1be
4 D F N P	1be 3 3f
4 J	3
4 S A Fn 2	3be
Fn 1 for 4 A-T	3bde
5 E-K	1be
6 D F H J N P S	2
Fn 1 for 6 A-T	2d
7 E G I O Q T A	
Fn 3 4 5	3bef
8 B F H J K S	2
8 E G O P T A Fn 4	1be
Fn 1 for 8 A-T	1bde
9 E-K	1be
10 G K O S	4 4f
Fn 1 for 10 T	4d
11,12 G E-K O P A	
Fn 1,2 6,7	4be
13,14 G E-K C Q L	
Fn 1,2,8	4be
13 F J N S	5
13 O Q T A Fn 2	5be
Fn 1 for 13 A-T	5bde
16 E-K	5be
17 B D F L N P S	
A Fn 2	5bef
17 19 H J	3
17 S A Fn 2	3be
Fn 1 for 17 19 A-T	3bde
18,20 E-K	9be
19 B D F L N P L	
Fn 2	3bef
21 B D F H J N P	2
21 E G O A Fn 2	3be
Fn 1 for 21 A-T	1bde
22 E-K	1be
23 G I O Q A Fn 1	6,6f
Fn 1 for 23 A-T	6d
24 25 G E-K O A	
Fn 1,10,11,12	6be
26,28 B D F L N P	
S A Fn 1,2	6bef
26,28 H J	6
27,29 E-K	6be
30 G O Q T A Fn 1,	
10	7be
30 J P	7
31 E-K	7be
32 F-K B-Q ST A	
Fn 1,10	7be
33 F H P S B	
Fn 1,13	8bef
34 B F J L O Q	8 9,8f 9f
34 G N P S A Fn 2	8be
Fn 1 for 34 A-T	8bde
35 G-K O Q T A	
Fn 1,2	9be
36 G N P S A Fn	
1,2	8be
37 F P	8bef
37 38 S A Fn 1,13	8be
38 F N P	9bef
39 D O Q	10,11,10f,11f
Fn 1 for 39 A-T	10,11d
40 B O Q T A	
Fn 1,14	10be

Data Coordinates and Footnotes	Contributors and References
41 B H P A Fn 1 2	12be
42 B P A Fn 1,2	12be
43 P	8,8f
44 F P A Fn 1,4	14bef
44 J N S	14,14f
45 B	13,13f
45 F P A Fn 1,2	13bef
46 B D F B-L N P	
S A Fn 1 2,53	16be
47 F H P	8,8e
48 B D F L N P S	
A Fn 1,2,53	16be
49 F H J N P S	11,11f
Fn 1 for 49 A-T	11d
50 G-K O QR T A	
Fn 1 13,53	17be
51 G-O N-S A	
Fn 1,13,54	18be
52 B G-O N-S A	
Fn 1 2 54	18be
53 G-O N-S A	
Fn 1,2 54	18be
54,55 B D F H P B	
A Fn 1,13 54	18be
56 G-O N-S A	
Fn 1,4 54	18be
57 H P	8,8e
58,59 G-O N-S A	
Fn 1,2,54	18be
60 D F H P S	19,19f
60 E G-K O Q T A	
Fn 13	19be
Fn 1 for 60 A-T	19d
61 G I O Q A	19bde
Fn 1 15	11be
62 O O Q S	8,20,21,8e,21f
Fn 1 for 62 A-T	8d
63 F O MPQ T	
A Fn 1,14 16	20be
64 65 F H S A	
Fn 1,14 17,18	21be
66 D F B-K N P A	
Fn 1,11,14	21be
67 D O Q T A	
Fn 14 19	9bde
68 B OR QP S	21,24,21f,24f
69 G-K H P T A	
Fn 1,11,14	21be
70 D F B-K H S	
A Fn 1,14	21be
71 E H-K O Q T	
A Fn 10,11,20	21be
72 F H P	8,8f
73 G-K O Q T	21be
74 D F J H P BE	
A Fn 55	25,25f
74 E O O Q T A	
Fn 1,10	25bef
75 E-K	25be
76 D F H-K H S	
A Fn 1,14	21be
77 F H S	21,21f
Fn 21 for 77 A-T	21d
78 G-K H P T A	
Fn 1,11,14	21be
79 D F J H P BE	
A Fn 55	25
79 E S O Q T A	
Fn 1,10	26be
80 E-K	26be
81 B S A Fn 10,22,55	26be
82 E G-K O Q T A	
Fn 10 20	21be

Data Coordinates and Footnotes	Contributors and References
83 D F H S A	
Fn 1,10	27be
84 F H J N P A	
Fn 23	27,27f
Fn 1 for 84 A-T	27d
85 F H-K H S A	
Fn 1,14	27be
86 F H	28,28f
87 D G-K O Q T A	
Fn 10,11,20	21be
88 D E-K H S A	
Fn 1,11,14	21be
89 D F J H BE	29
89 H O QP T A	
Fn 10	29be
Fn 1 for 89 A-T	29d
90 E-K	29be
91 D F H S A	
Fn 10,19	29be
92 E G-K O Q T A	
Fn 1,11,14	21be
93 F H S A Fn	
10,19	29bef
94 95 D F H	29be
94 S A Fn 10	29be
Fn 19 for 94 95	
A-T	29bde
Fn 1 for 95 A-T	29bde
96 F H P A Fn 2	29bef
Fn 24 for 96 A-T	29bde
97 F H H P A	
Fn 23 30	24,29be
Fn 2 for 97 A-T	29be
Fn 24 for 97 A-T	29bde
98 B F H P	30
98 P T A Fn 2	30be
Fn 1 for 98 A-T	30bde
99 B F J H P	31,31f
Fn 24 for 99 A-T	31d
100 E G O Q A	
Fn 2,24	31be
101 103 B F H P S	
A Fn 2,24 26,27	31be
104-106 F H P A	
Fn 28,29	33e
107 F H P	32,33e
Fn 30 for 107 A-T	33e
108,111 B F H P	33e,34
Fn 31 for 108,111	
A-T	33e
109,110,112 B F H	
F A Fn 2,31	34be
113 D F H Y	33e
114 F H P	33e
115 F H P S A	
Fn 2 24	36be
116 H P	8e 33e
117-119 E G H O T	
A Fn 14 32,33	36be
120,121 E G H T A	
Fn 32,33	36be
122 E G H O T A	
Fn 10,32 34	36be
123 D F L H P	20f 33e,37be
123 B	20
123 P A Fn 10	37be
Fn 1 for 123 A-T	37bde
124 F G A Fn 37	38be
124 H P	38
125 D F L N P	20,20f
125 E G H O T A	
Fn 10,19	13,20be
126,127 B F L H P	33e

(Continued on the next page)

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
127 E G H O Q T	13be,20,24be	152 T	39	178,179 E H OP	43
Fn 1 for 127 A-T	13,24abe	153 E F L N P S & Fn 14 19 36	39be	178,179 F & Fn 11, 12	13be 43
Fn 10 for 127 A-T	13,24be	154 F N P S & Fn 14 19 35	39be	180 F N P & Fn 1	8,44
128 B F L N P	20	155 D F L N P S & Fn 14,19,36	39be	181 D F N P S & Fn 10,45	13be
128 E G H O Q S & Fn 14 19	24be	156 D F L N P	13,37be	182 D F L N S	13,20be 43
129 130 D F L N P S & Fn 11, 12	13be,33e	156 S & Fn 10,19	37be	182 P	43
Fn 14 19 for 129 130 A-	13be	157 D F N P S & Fn 10,38	37be	Fn 10,19 for 182 A-T	13,20be
131 E G O Q ~ A Fn 14 32	36be	158 F & Fn 41	20	183 D F L N S	37,43
132 E G H Q T A Fn 14 32	36be	159,160 F G & Fn 14 42,43	40be	183 E G H O T & Fn 10,19	13 37bef
133 E G H T A Fn 10 32,34	36be	161 D-G L-N P ST & Fn 10,19	39be	183 P	13 37be 43
134 135 E G H Q T & Fn 2,32	36be	162 F S & Fn 14 19 35	37be	184 185 D F N	37,43
136 D G L N P	36	163 D F L S & Fn 14 19 36	39be	184 185 E G O & Fn 10,19	13,37be
136 E G H O Q T & Fn 1,10	13,24be	164 D F N P S & Fn 10,38	37be 43f	184 P T	13,37be,43f
137 D G L N P	8,13,24be	165 D F L N S & Fn 2,11,40	13be	185 H P T	13,37be 43f
137 E & Fn 10	13,24be	166 D F N S & Fn 2,12,40	13be	186 F N	20
Fn 1 for 137 A-T	13,24abe	167 E-G H OP & Fn 2,12,44	13,20,37be	Fn 19 for 186 A-T	20d
138 D F N P S & Fn 10 19	13,24be	168 F G & Fn 2 12,24	41be	187 F N & Fn 14 19	43be 53e,54e
139,140 D F L N P S & Fn 10,19 35,36	35be	169 E G L OP ST & Fn 2,11,44	13 20,37be	187 P	43 53e 54e
141 D G H O Q T & Fn 10 19	24be	Fn 2 for 169 A-T	37be	188 F & Fn 14 19	46be
141 F N P	37	170 F N & Fn 2,11	41be	188 N	46
142,143,145 D F L N P S & Fn 10 19 37 39	13be	Fn 41 for 170 A-T	13,20d	189 F N P & Fn 46	47 48
144 F L N S & Fn 10 19 39	13be	171 D P	42	189 F & Fn 14,19	47 48be
146 D F L P Q	39	171 F J N & Fn 2	40be	190 F & Fn 19,47	49
146 E T	39be	Fn 1 for 171 A-T	40d	191 N & Fn 14 19 38	46be
147 E G L O Q T & Fn 2,40	13be	172,173 F N & Fn 2,40,43	40be	192 F N & Fn 11, 14,19	49be
148,149 D F L N P S & Fn 2,11,12, 40,37	13be	174,175 D G L N P S & Fn 11,12, 14 19	37be	193 F & Fn 14 19 48,49	49be
150,151 E G H O Q & Fn 2,11,12,40	37be	176,177 NO & Fn 14,19,42,43	40be	194 F & Fn 14 50 51	49be
152 D F L N P S & F 14,19 35	39be	178,179 D L N S & Fn 14 40	13be	Fn 19 for 194 A-T	49d
				195 F & Fn 14 19	50be
				196 F & Fn 52	46,51d
				196 N	46d
				Fn 19 for 196 A-T	46,51d
				197 N & Fn 14,19 38	46be
				198 F & Fn 14	52be
				198 N	52
				Fn 19 for 198 A-T	52bde

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Data Coordinates and Footnotes	Contributors and References
1 B	1,2,g,3a,81j
1 C	1a,4,5f,6f,81j
1 E	1a,7a,9a
2 B	2
2 C	1a,4a,5,6
2,3 D	8a
2 E	8a,9a
3 B & Fn 2	Calc from 7 11 BC See also 1a,2a, 3j,10-16a
3 5 C	3j,1a,2a,4a
3 EFG	17a
4 C	10-16a
5 FG	17a
6 BC	Calc. from 18-71 BC
6 FG	29ik
7 B	14,2,3j,11j,80a, 81-84d
7 C	3j,5f,6,6efmo,11a, 25-28a
7 F	29ik
7 G	29ik,30b
8 B	14,2,80a,81-84d
8 C	1a,5f,6f 3f
9 B	14,2,3j,81-84d
9 C	1,3j 5f,6f,35a 36a
9 FG	35ik,36ik,81a
10 B	14a,2,6,80a,81-84d
10 C	1,1a,37-39a
10 F	40a
10 G	40ab
11 B	14,2 3j,80a,81-84d
11 C	14,3j,5f,6f,11a, 41 41-43a
11 E	44a
11 G	45ik,46ik
14 B	47a
15 B	48,49aj
15 C	47a,48,49bja,50-56a
16 BC	48
17 C	47a,49a,50-53a, 54aja,55-57a
17 D	59a
17 E	59a
17 FG	60abik
18 B	48,48a,49aj
18 C	47a,48,49bja,50a, 54a,55a
19 BC	49
20 BC	47a,49a,50a,54a, 57a
21 BC & Fn 3	81j,x
23 C	68a
24 B	48,49dj,57a 63a
24 C	48,49aj
26 C	49a,63a,64a

Data Coordinates and Footnotes	Contributors and References
27 B	48,49aj
27 C	48,48a,49aj,50a, 54a,57a
28 BC	48
29 B	49j
29 C	49j 54e
30 B	47a,54bja,57a
30 C	54a
32 C	47a,54aja,57a
33 B	48,49aj
33 C	47a,48,49aj 54a,57a
34 BC	49
35 BC	49j 54e
35 D	59a
35 E	59a
35 FG	60abik
38 B	47a
39 B	48,49aj
39 C	47a,48,49bja,50a, 52a,53a,55-57a,63a
40 BC	48
41 BC	47a,49a,50a,52a, 53a,54e 55-57a,63a
41 D	59a
41 E	59a
41 FG	60abik
42 B	48,49aj
42 C	10a,48,49bja,50a, 52a,53a,55-57a,63a
43 BC	48
44 B	49j
44 C	10a,49ja,50a,52a, 53a,54e,55-57a,63a
44 D	59a
44 E	59a
44 FG	60abik
45 B	48,49aj
45 C	10a,47a,48,49aa, 50-57a
46 BC	48
47 BC	10a,47a,49a,50-53a 54aa,55-57a
47 D	59a
47 E	59a
47 FG	60abik
48,49 B	48,49aj
48 C	10a,47a,48,49bja, 52-57a,63a,66a
50 BC	48,49aj
51 B	47a
54 B	48,49ah
54 C	47a,48,49gia,50a 53-55a,57a,63a
57,58 BC	48
58 BC	47a,49a,50a,53-55a, 57a,63a
56 FG	60abik
57 B	48,49bja
57 C	48 49aj

Data Coordinates and Footnotes	Contributors and References
59 BC	49a
60 B	47 50a,64j
60 C	50a,64j
61 BC	47a,50a
62 BC	47a,50a
63 B	48 49aj
63 C	10a 47a,48 49aja, 50a,52-57a,64a
64 BC	48
65 BC	10a,47a 49-53a, 54aa,55-57a,64a
65 D	59a
65 E	59a
65 FG	60abik
66 B	48 49aj
66 C	47a,48 49aja,50a, 55-57a,63a,64a
67 BC	48
68 BC	47,49a,50a,55-57a, 63a,64a
68 FG	60abik
69 B	48 49j
69 C	48,49gka 50a 57a 63a
70 BC	48
71 B	49j
71 C	49j,54e
71 FG	60abik
72 B	48,49aj
72 C	10a,48,49aja,50a 52-57a
73 BC	48
74 B	49j
74 C	10a,49ja,52a,53a, 54aa,55-57a
74 D	59a
74 E	59a
74 FG	60abik
75 C	47a
76 B	2,81-84d
76 C	14 3f,32,67a
77 BC	68ae,69ao
78 C	68a
79 B	2,80a,81-84d, 70gm 71j
79 C	14 3f 70 70a 71j 72a,73a
80 B	68ae,69ao
81 B	2,81-84d,74j
81 C	14,2a,3f 74j
81 E	73a
82 C	80a
83 C	76a,77a
84 BC & Fn 7	11j
85 C	69ao
86 B	1
86 C	1 78a,79a
86 E	80a

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
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1 E	1b,8d	5 DE	8d	7 10 E & Fn 6	6aa
2 DE	8d	5 E	2a	11 DE	7ad
3 DE & Fn 5	3bd	6 E & Fn 4	6ad	12-14 E & Fn 7	6aa
		7 C	7		

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
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2 C	6a,7 8a,9a,10j	10 D	17a	16 BC	41b
2 D	11a	10 E	17aj	17 B	41a,42j
2 E	11a,12j	10 G	34a	17 C	40j,41aj 42j,43j
2 G & Fn 2	13a,14gi	11 B	30a	17 F	40a
3 B	15-17j 18a	11 C	30aj 34aj	18 B	44j,45a
3 C	15,15a 18a	12 B	,17a	18 C	8a,44,44j,45aj
3 D	17a	12 C	17aj,36j 35aj		46 45-48j
3 E	17aj		36j,37j	18 D	17a
3 F & Fn 3	19gi	12 D	17a	18 E	17aj
4 E & Fn 4	20j	12 E	17aj	18 G	14gi,49a
5 B	21a	12 FG	30bgi	19 B	50a
5 C	21aj,22j	13 B	17a	19 C	8a,25j,50 51,
5 G	21bgi,f	13 C	17aj,36j,39j		51-54j
6 B	24a,25j	13 D	17a	19 D	17a
6 C	24a	13 E	17aj	19 E	17aj
7 DE	26a	13 F	19gi	19 FG	49aj
8 B	27	13 G	19b	20 C	38j 53j 55j
8 C	17j 24j,27a	14 C	38j	21 C	56j
8 D	17a	14 D	17a	22 C	57j,58j
8 E	17aj	14 E	17aj	23 C	59-61j
8 F	28a	14 F	40gi	24 B	62j,63j
8 G	28gi	14 G	40a	25 C	64j
9 DE	19j,29j	15 B	41a		
9 F	19gi				

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116. EXCRETION OF MISCELLANEOUS ORGANIC COMPOUNDS: MAN

Data Coordinates and Footnote	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	1 54	5 F	18a	10 E	331
1 C	6-121	6 C	191,201	10 G	34gh
2 C	1,20e 43e	7 C	47 501	11 B	351
2 F	44a	8 B	211	12 C	36-391
2 G	44gh	8 F	22gh,23gh	13 C	311
3 B	1 54,541	8 G	22ghi,23ghi	14 C	39 39f 40 40f
3 G	431	9 B	1 52	14 D	411
4 DE	4?21	9 C	24,24-271	14 E	421
4 G	46a	10 B	1 52,24	15 C	20e
5 C	13,13f,14-171	10 C	28,20e,29 30-321		

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117. EXCRETION OF ELECTROLYTES AND MINOR MINERALS: MAN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 CD	1q	9 C	31a	19 B	2,3m,5-8e,27m,34a
2 B	2 3g,4-8e 9m	10 B	5-8e 37 38j4,53a 72j	19 C	4q,2m,27m,34a
2 C	9m,10,10q,11f 12f 13-15q	10 C	4q,11f 38qj,75a 74q,72f8,56q	19 D	30qr
2 E	16q	10 G	371 38e	19 G	71a
2 G	17me 18me	11 B	5-8e	20 DE	72a
3 BD	19m,q	11 C	4	21 B	73q
3 DE	20a	11 D	39a,60a	21 C	74-76q
4 C	21q,22q	11 E	39a,60aq	22 D	1q
5 B	2 5-8e 23	11 FG	3261	23 B	2,3m,4am,5-8e,27a, 73m,77a
5 C	2,3q,4q,10q,11f, 12f,24m,25a,26e, 27q	12 B	1q,4-8e 19a	23 C	3m,4m,11f 12f,27m 33m,77a,78
		12 C	1q,4,19a	23 D	30q
		12 D	1q,60a	23 G	37a,39a,57b
5 D	28a	12 E & Fe T	66a	24 B	12q,73m
5 E	29q,30qr,8eq	13 B	2 5-8e,27m,62a	24 C	3q,17m,60q,11f
5 FG	31me 321	13 C	4q,11f,12f,27m 30q, 63m,64aq,65q,66q	24 D	30q
6 B	2,3m,5-8e,27m, 33m,34a	13 D	30qr 66aq	24 G	70me
6 C	3m,4q,10q,11f,12 12f,30q,33m,34e, 35,35q	13 E	66a	25 B	3q,73m
		13 FG	31me 30q	25 C	3q,11f,12f 60q
		14 C	1,1q,67q	26 B	12q,73m
		14 E	1q,67q	26 C	3q,73m,80q
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6 E	56a	14 FG	50aq	27 B	3q,79a
6 G	38a,59bc,85b	15 CD	68d	27 C	2,3q,79a,80q
7 BD	2 40q	16 B	4	28 C	1,1gq,67q
7 DE	40a	16 CE	67q	28 E	1q,30qr
8 B	4-8a 41-46j,47a	17 B	2,4q	29 B	83q,81a,84q
8 C	1,1q,41jq,42-46j 47m,48q,49q	18 B	2,3q	29 C	81a
		18 C	3q,4q,6 30q,69q	29 D	81a
8 D	1q,42a	18 D	30qr 59a	29 E	81a,82bq,83q,84q
8 E	42a	18 E	59a		
8 F	50b	18 FG	70ao		

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(Continued on the next page)

Data Coordinates and Footnotes	Contributors and References
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1 C	2a
2 B	148a,150a 178e 176e
2 C	148a,150a
3 BC	31a
4 B	78ae
4 C	77e
5 BC	160a
6 BC	67ae,68a
7 BC	67ae,68a,69a
8 9 BC	67ae,68a
10 B	75a 76a,77a 76a, 79a,169e
10 C	169e
11 B	58ae 59a
11 C	58e
12 B	a-59ae 90a 78e 69e,191e,201a 202e,225e,224b
12 C	29e,201e,202e
13 B	229e
13 C	289a
14 B	229e
14 C	289e
15 B	69ae
15 C	69a
16 B	250e
17 B	30a
18 BC	57ae
19 BC	7a 178e,176e
20 B	3a 4a 5a,178e 176e,215a
20 C	3a 4a,5a 178e 176e
21 BC	28a,25a
22 B	1a
23 B	5a,11e,18a,19ae 49e
23 C	5a,18a 19a
24 BC	20a,131e
25 B	170a,171ae
25 C	196e,197
26 BC	49ae
27 B	50a,221e
27 C	221e
28 B	230e,231e
28 C	230e
29 B	169a
30 BC	57e
31 B	58a,59ae 78e,148e 191e,199e,226e
31 C	58a,59e
32 B	47a
33 BC	45a,46a
34,35 B	21a
36 BC	56a
37 BC	6ae
38 B	48a
39 B	6ae 149e,150e
39 C	6e
40 B	66ae,190e
41 B	5a,24ae,25e,26a, 27 ,26a,191e 200c
41 C	5a,24a,25e,26a
42 B	25ae
42 C	26a,20e
43 BC	54a
44 BC	73a 74a,195e,194e 195e
45 BC	4a,11ae,211
46 BC	15a
47 BC	14a
48 B	56a,49e 190e 191e
48 C	56e
49 BC	40a,41a
50 B	56ae 57ae,205e

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51 B	8ae
51 C	8e
52 B	48ae
52 C	48a
53 BC	67ae,68a
54 B	54ae
54 C	54a
55 BC	51a,61ae,68a
56 B	5a 18ae 13a,80e 165a,164e,205e
56 C	5a 12a,13a
57 B	172ae
57 C	172a
58 B	71a,205e,207e 206a,208e
58 C	71a,208e
59 BC	51ae 58a
60 BC	51a 58a,220ae
61 B	51a,58ae
61 C	51a 58a
62 B	51ae 58a,219e
62 C	51a,58a
63 B	9a
64 B & Fn 5	63ae 64a,218e
64 C	63a,64a
65 B & Fn 5	63e 64a,219e
66 B	10a,213e 214e
66 C	213e
67 B	43a,44e
68 B	60ae
69 BC	32ae,33a,34ae
70 BC	64a,65ae
71 B	4ae 5a,16a,17a, 52e 60a 98a,94a 178e
71 C	4a 5a,16a,17a
72 B	54a,55aed,217 218e
72 C	55e,217e,218e
73 BC	60a,70e
74 B	70ae
74 C	70a
75 B	55ae
75 C	55e
76 B	110ae,173d
76 C	173d
77 BC	110aed,111ac
78 B	87aed,88a,89a 90a
78 C	87ae,88a,89a 90a
79 BC	81a,88a 180d
80 BC	183d
81 BC	106d
82 B	106aed 107
82 C	106ad
83 B	94a 95ae 96aed 97 ,100d,174d
84 B	181ad
85 B	105ad
86 B	80ae 98ae 93ae
86 C	80a 98ae 97ae
87 BC	91ae 98a
88 B	110aed 111a
88 C	110e
89 B	94a 96ao 97ad 173d,216e
89 C	216e
90 B	101aed
90 C	101d
91 B	159d
92 B	185d
93 B	99aed 100ad
93 C	99e
94 B	87aed,88a,89a 90a
94 C	87e,88a,89a 90a
95 B	180ae

Data Coordinates and Footnotes	Contributors and References
95 C	180a
96 BC	85ae 86a
97 B	109a
98 B	226a
98 C	286e
99 B	94a 95aed 96ao 97e,174d 177d 216e
99 C	94a,95ae 96a 97 174d,177d
100 B	101aed,108a 103ad
100 C	101e
101 B	85a
102 B	96aod
102 C	96ad
103 B	117 118ae
103 C	118e
104 B	118a 173ad
104 C	173d
105 B	225o
106,107 B	188a
108 B	186d
109 B	116ae
109 C	116ae
109 B	119a
110 B	117a,118ae
110 C	118e
111 B	119a
112 BC	108aed 180d
112 C	88a 99aod
113 BC	113a,114a,115ae 222e,226c
114 B	88ae 99aed,198e
114 C	88a 99aed
115,116 BC	99ae
117 B	104aod,111d
117 C	104ad,111d
118 BC	110aod,111aed 181ad
119 B	105a
120 B	28Te
121 B	69ae,83ae,84ae
121 C	84e
122 B	115a
123 B	94a,96aod,174d
123 C	96e
124 B	131ae,67e
124 C	131a
125,126 B	125ae,124a,125a 126a
125,126 C	125a,124a,125a 126a
127 BC	127ae,128a
128 & Fn 12	186d
129 BC	129aod 130a
130 B & Fn 13	140a
131 B & Fn 14	7a,36a,136a
132 BC	143a 144a
133 BC & Fn 15	141a
134 BC & Fn 16	138a,133a
135 B & Fn 14	135a
136 BC & Fn 14	134ae
137 B & Fn 17	138a
138 B	67ae,139a
138 C & Fn 17	67a,139a
139 B	67ae
139 C & Fn 18	67
140 B & Fn 17	140a
141 B	137ae
141 C & Fn 14	137a
142 B	148ae
142 C & Fn 19	148a
143 BC	155a
144 B	139a
145 B	96a,104a,143a,146a, 165a,209a,210e
145 C	210e

(Continued on the next page)

Data Coordinates and Footnote	Contributors and References	Data Coordinate and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
146 B	147ae	151 C	145ae,146a	157 B	160ae,161ae 160a
146 C	147	152 BC	178d,187d	157 C	161ae
147 BC	148a 149a,150a	153 B	167a,198a	158 B	158a,178d,179d
148 B	153a	153 C	192b	159 BC	166a
149 BC	154a	1,4 B	158a,178d,179d	160 B	156a,157
150 B	151a,152a	155 B	179a	161 B	153a
151 B	145ae,146ae,210e	156 B	178d,188d	F 1	

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Reviewers: Gould B. S.; Mandel J A.; Moyer A. J; Nord F F; Pratt R.; Raistrick H.; Ward D D

119. PRODUCTS OF CARBOHYDRATE METABOLISM AS AFFECTED BY CHANGE IN pH: YEASTS AND BACTERIA

Data Coordinates and Footnotes	Contributors and References
1-10 [illegible]	1a
1-10 HI	2a
1-10 JK	3a

Contributor: ( ) Ledingham, G A.

References: (1) Neish, A C., and Ledingham, G A., Canad. J Res B27:694 1949 (2) Neish A. C and Blackwood A. C (unpublished) (3) Neish, A C and Blackwood, A. C Canad J Technol. 29:123 1951

Reviewers: Atkin L.; Dunn, C. G; Ledingham, G. A.; Pergus [illegible]; Stanier R. Y; Umbreit W W; Underkofler L. A.

120. PRODUCTS OF CARBOHYDRATE METABOLISM OF INDUSTRIAL IMPORTANCE: BACTERIA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABCD	1b	3 ABC	a	5 ABCD	a
2 A CD	1b	4 A C	1b	Fn 1,2	a
2 B	a,1b	4 B D	a,1b		

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References (1) Prescott, S. C and Dunn, C G Industrial microbiology, New York: McGraw-Hill, 1949

Reviewers: Dunn C G.; Umbreit W W

121. METABOLIC PRODUCTS OF BACTERIA: ANAEROBIC FERMENTATION OF GLUCOSE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
7 B	1b	1 3 9,13,14 F	4b	1,2 4,6 9,11,15 15 I	6b
1 4 7 9,12 C	2b	3,4 7-9 G	4b	1,2,4,6,10,11 J	7b
1 4 5,8 D	3a	1,2,4,6 H	5b	1,2 4 7-9,13,14 K	8b
1-4 7-9 E	4b				

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Reviewers Delwiche E. A ; Sherman, J M.; Umbreit W W ; Werkman, C H.

122. OXYGEN CONSUMPTION: BLOOD FORMED ELEMENTS, MARROW, SPLEEN, LYMPH NODES, THYMUS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	9 ABC	11a	18 ABC	13a,14a,24a
2 ABC	1ab	10 ABC	2a,5a,12a	19,23 ABC	16a
3 ABC	2a	11 ABC	13a	20 ABC	16a,17a
4 ABC	3ac	12 ABC	6a	24 ABC	27a
5 ABC	3a 4a	13,15 21,22 ABC	15a,14a	25 ABC	13a,20a,21a,22a,23a
6 ABC	4a	14 ABC	15a	26 ABC	6ac
7 ABC	3a,6ac	16 ABC	16a	27 ABC	9a,11a
8 ABC	6a,9a,10a	17 ABC	19a	28 ABC	10a

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References: (1) Warren, C O., Jr Am. J Physiol. 131:176 1940. (2) Glover E. C Daland G. A. and Schmitz H. L. Arch. Int. Med. 46 46 1930. (3) Fleischmann, W. and Kubowitz F Biochem. Ztschr 181 395 1927 (4) Macleod J and Rhoads C. P Proc Soc Exp. Biol. Med. 41:268 1939. (5) Fujita A. Klin. Wchnschr 7:897 1928 (6) Fujita, A. Biochem. Ztschr 197 175 1928. (7) Polley H J , and French T H. Biochem. J 45:270 1949. (8) Rosenthal, O. and Lasnitzki A. Biochem. Ztschr 196 340 1928. (9) Warburg O. Posener K., and Negelein, E. Biochem. Ztschr 152:309 1924 (10) Wahlgren, J and Klopstock E. Biochem. Ztschr 173:202 1926 (11) Barker S. B. and Schwartz H. S. (unpublished) (12) Endres G. and Kubowitz F Biochem. Ztschr 191 395 1927 (13) Ramsey, R. and Warren C O., J J Exp. Physiol. 20:213, 1930. (14) Ibid. 20:49, 1930. (15) Kurashima T J Biochem. (Tokyo) 4 411, 1925. (16) Negelein, E. Biochem. 158:121 1925. (17) Schlayer C Biochem. Ztschr 293 94 1937 (18) Wright H. P J Gen. Physiol. 14 179 1930. (19) Barker S. B. and Klitgaard, H. M. Am. J Physiol. 170:81 1952 (20) Dickens F. and Greville G. D. Biochem. J 27 832 1933. (21) Dickens F and Simer F Biochem. J 24 1301 1930. (22) Murphy J B. and Hawkins J A. J Gen. Physiol. 8 115 1925. (23) Weil-Malherbe H. Biochem. Ztschr 172:202 1926. (24) Engelhardt W A. Biochem. Ztschr 251 343 1932 (25) Dixon, K L. and Leblair L. P Biochem. J 50:319, 1954

Reviewers Barker S B. Dickens F Jandorf B J Krebs H. A. Macleod, J Quastel J H Schofield R G

183 OXYGEN CONSUMPTION: EPITHELIUM AND ASSOCIATED TISSUES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	7 ABC	4a 5a,6a	13 ABC	10ac
2 ABC	1a,2a	9 ABC	7a	14 ABC	10a
3 6,8 ABC	2a	10 ABC	8b	15 ABC	11a
4 ABC	1ac	11 ABC	9ac	16 ABC	11a,12a
5 ABC	3a	12 ABC	9a		

Contributors: (a) Barker S. B (b) Jandorf B. J (c) Quastel, J H and Scholefield, P G.

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Reviewers Barker S. B.; Dickens F; Jandorf B. J; Krebs H. A.; Moore R. O.; Quastel, J H.; Scholefield P G

184 OXYGEN CONSUMPTION: GLAND TISSUES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	7 9,20 ABC	4a	21 ABC	3a,7ab
2,3,11,12 ABC	1ab	8 ABC	3ab 10b	22,24,25 ABC	8a
4,16-19 ABC	2a	10 ABC	5a	23 ABC	9ab
5 ABC	5ab	13 14 ABC	6a	26 ABC	7a
6 ABC	4ab	15 ABC	7ab	27 ABC	3a,11a

Contributors ( ) Barker S. B. (b) Quastel, J H. and Scholefield, P G

References (1) Fujita, A. Biochem. Ztschr 197:175, 1928. (2) Deutsch, W, and Raper H. S., J Physiol. 87:275, 1936. (3) Warburg, O, Posener K. and Negelein, E. Biochem. Ztschr 152:309 1924. (4) Dixon, K L. and Leloir L. F Biochem. J 30:1519 1936 (5) Barker S B. and Schwartz H. S. (unpublished) (6) Roberts S, and Bosk, K. (unpublished) (7) Rosenthal, O and Lasnitzki, A. Biochem. Ztschr 196:340, 1928. (8) Barker S. B. (unpublished) (9) Sturm, A. Ztschr exper Med. 74:555 1930 (10) Mendel, B. Klin. Wschr. 10:118, 1931. (11) Walthard, B Ztschr exper Med. 79:451, 1931.

Reviewers: Barker S. B.; Dickens F; Jandorf B. J; Krebs H. A.; Moore R. O.; Quastel J H.; Scholefield, P G.

185 OXYGEN CONSUMPTION: LENS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 6 7 ABC	1a	4 ABC	3ab	9 ABC	1a,6ab
3,8 ABC	2a	5 ABC	4a,3ab	10 ABC	4ab

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References: (1) Field, F P Potts A. M and Gerard, R. W J Biol. Chem, 167 505 1947 (2) Dixon K L. and Leloir L. F Biochem. J 30:1519, 1936 (3) Krebs H. A. in Oppenheimer C Handbuch der Biochemie des Menschen und der Tiere, Jena, Germany: Fischer 1933 (4) Fujita, A. Biochem. Ztschr 197 175, 1928. (5) Ogata, Y Jap J Med. Sci Trans III Biophysics 2:131, 1932 (6) Laser H. Biochem. Ztschr 264:9 1933

Reviewers: Barker S. B. Dickens F Jandorf B. J Krebs H. A. Quastel J H. Scholefield P G.

126. OXYGEN CONSUMPTION: LIVER

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2,3 ABC	1a	9 ABC	6ab	15 ABC	14a
4,10 18 ABC	2a	11 ABC	8ab	16 ABC	15a,16a,17a
5 ABC	3ac	12 ABC	9a,10a	17 ABC	8a,9a,15a,16a,17a, 19a,20a,21a,22a, 23a,2a
6 ABC	4a	13 ABC	11ac,8a		
7 ABC	5ac	14 ABC	13a		
8 ABC	5a				

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References (1) Carroll, W. J Arch. f exper Pathol Pharmak 89:598, 1939 ( ) Kleiber M. Proc Soc Exper Biol Med. 48:419 1941. (3) Krebs H. A. in Oppenheimer C Handbuch der Biochemie des Menschen und der Tiere, Jena Germany: Fischer, 1933. (4) Elson, H. L. and Lelein L. R. Biochem. J 30:2319, 1936 (5) Meier R. and Thelemann K. Arch. exper Path. Pharm. 169:675, 1933 (6) Tonyia, C. Biochem. Ztschr 189:179 1927 (7) Deutsch, W and Raper H S. J Physiol. 87 275 1936 (8) Ogata, Y Jap. J Med. Sci. Trans III Biophysics 4:131, 1938. (9) Crabtree H G. Biochem. J 22 536, 1928. (10) Laser H. Biochem. J 31 1671, 1937 (11) Shima, T Tohoku J Exper Med. 15:465 1929 (12) Burk, D. Cold Spring Harbor Symp. Quant Biol 7:420, 1939. (13) Rosenthal, O and Lasnitzki A Biochem. Ztschr 196 340, 1928 (14) Hawkins J A. J Gen. Physiol 11:645, 1928. (15) Dickens, F and Greville G. D Biochem. J 27:1082, 1933 (16) Meyerhof O. and Lohmann, K. Biochem. Ztschr 171 381,421, 1926. (17) Himwich H. Biochem. Ztschr 163:334 1925 (18) Barker S. B., and Klitgaard, H. M. Am. J Physiol. 170:81, 1952 (19) Dickens F and Simer F Biochem. J 24 1301, 1930 (20) Elliott K. A. C Greig, M. E. and Benoy M. P Biochem. J 31 1003 1937 (21) Grassheim, K., Ztschr klin. Med 103 380 1926. (22) Meyerhof, O Lohmann, K, and Meier R Biochem. Ztschr 157 459, 1925 (23) Warburg, O Posener K. and Negelein, E Biochem. Ztschr 152 309, 1924

Reviewers Barker S. B.; Dickens F; Elliott K. A. C; Jandorf B. J; Kleiber M.; Krebs H. A.; MacLeod J; Quastel, J H.; Scholefield P G.

127 OXYGEN CONSUMPTION: MISCELLANEOUS TISSUES, COMPARATIVE

Reference Data contributed by Quastel, J H. and Scholefield, P G and adapted from Krebs, H. A Biochim. et Biophys Acta 4:249, 1950

Reviewers Barker S. B; Dickens F; Jandorf B J; Krebs, H A.; Moore R. O Morrison, P R. Quastel J H; Scholefield, P G;

128. OXYGEN CONSUMPTION MISCELLANEOUS TISSUES IN THE PRESENCE OF VARIOUS SUBSTRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-6,8,14-20,23		9 ABC		F 2-4	5a
24 ABC	1ab	10-13,25-27 ABC	3a	Fa 5-7	4a
7 ABC	2a	21,22 ABC	4a		

Contributors ( ) Barker S. B. (b) Quastel J H. and Scholefield P G

References (1) Jowett M. and Quastel J H. Biochem. J 31 565 1937 (2) Lasa R. Biochem. Ztschr 248:9 1932 (3) Lasor H. Cold Spring Harbor Symp. Quant Biol. 7 325 1939 (4) Crabtree H. G Biochem. J 22:536 1928. (5) Meyerhof O Lohmann K. and Meier R. Biochem. Ztschr 157 459, 1925

Reviewers Barker S. B.; Dickens F; Jandorf B. J; Krebs H. A.; Moore R. O; Quastel J H.; Scholefield P G.;

129. OXYGEN CONSUMPTION: MUSCLE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinate and Footnotes	Contributors and References
1,2,8 ABC	1a	10,14 ABC	2a,9a	16 ABC	2a
3 ABC	2a,3a,4a,5a,6a	11 ABC	5a,10a,11a,12a,15a	18 ABC	11ab
4 ABC	6a	12 ABC	10a,12a	21 ABC	13a
5,9,17 ABC	7a	13 20 ABC	5a	22 ABC	14a
6,7 ABC	8a	15 19 ABC	14ab		

Contributors: (a) Barker S. B. (b) Quastel J. H. and Scholefield P. G.

References: (1) Barker S. B. (unpublished) (2) Barker, S. B., and Klitgaard H. M. Am. J. Physiol. [illegible] 1952 (3) [illegible], F. L. and Leloir L. F. Biochem. J. [illegible] 1941. (4) Connell, C. L., Bull. Johns Hopkins Hosp. [illegible] 1941. (5) Meyerhof O., Lohmann, K. and Meier R. Biochem. Ztschr. [illegible] 1925 (6) Tabor R. Biochem. Ztschr. [illegible] 1926. (7) Shorr, E. Cold Spring Harbor Symp. Quant. Biol. [illegible] 1939 (8) Warburg, O. Posener K. and Negelein, E. Biochem. Ztschr. [illegible] 1924 (9) Field, J. 2nd in Potter V. R., Methods in medical research, Chicago: Year Book Publishers 1948 (10) Connell C. L. Am. J. Physiol. [illegible] 1937. (11) Meyerhof O. and Lohmann, K. Biochem. Ztschr. [illegible] 1926. (12) Cohen, [illegible] Biochem. Ztschr. [illegible] 1930. (13) Maslow, [illegible] J. Cell Compar. Physiol. [illegible] 1937 (14) Rosenthal O. and Lasnitzki A. Biochem. Ztschr. [illegible] 1928. (15) Dickens F. and Weil-Malherbe H. Biochem. J. [illegible] 1941

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130. OXYGEN CONSUMPTION: NEOPLASMS BENIGN AND HYPERPLASTIC TISSUE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1ab,2ab	3,4 5 ABC	3a	8 ABC	4ab
2 ABC	2a	6,7 ABC	1a,4ab	9 ABC	5a

Contributors: ( ) Barker S. B. (b) Quastel, J. H. and Scholefield P. G.

References: (1) Rosenthal, O. and Lasnitzki, A. Biochem. Ztschr. [illegible] 1928 (2) Waltherd, [illegible] Ztschr. [illegible] 1931. (3) Warburg, O. and Kubowitz, F. Biochem. Ztschr. [illegible] 1927 (4) Warburg, O. Posener K. and Negelein, E. Biochem. Ztschr. [illegible] 1924 (5) Crabtree H. G. Biochem. J. [illegible] 1928.

Reviewers: Barker S. B. Dickens, F. Jandorf B. J. Krebs H. A. Quastel J. H.; Scholefield, P. G.

131. OXYGEN CONSUMPTION: NEOPLASMS MALIGNANT

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,13 ABC	1a	5,6 ABC	7a	10 ABC	10a,12a,15a
2 ABC	1a,2a,3ab,4a,5a	7 ABC	8a	11 ABC	16a
3 ABC	4a,5a	8 ABC	6ab 9a	12 ABC	4b 6a,9a,17b
4 ABC	6a	9 ABC	6a,11a,12a,13ab,14a		

Contributors: ( ) Barker S. B. (b) Quastel, J. H. and Scholefield, P. G.

References: (1) Murphy J. B. and Hawkins J. A. J. Gen. Physiol. [illegible] 1925. (2) [illegible], R. O. Biochem. Ztschr. [illegible] 1930. (3) [illegible] Biochem. Ztschr. [illegible] 1929 (4) Rosenthal, O. and Lasnitzki A. Biochem. Ztschr. [illegible] 1928. (5) Warburg, O. Posener, K. and Negelein, E. Biochem. Ztschr. [illegible] 1927 (6) Crabtree, H. G. Biochem. J. [illegible] 1928. (7) Glover R. C. Daland, G. A. and Schmitz, H. L. Arch. Int. Med. [illegible] 1930 (8) [illegible], E. [illegible] F., and [illegible] D. Biochem. J. [illegible] 1933 (9) Laser H. Biochem. J. [illegible] 1937 (10) Crabtree H. G. Biochem. J. [illegible] 1928 (11) Dickens F. and Simer F. Biochem. J. [illegible] 1930 (12) Dickens, F. and Simer F. Biochem. J. [illegible] 1930 (13) [illegible] Biochem. Ztschr. [illegible] 1925. (14) Weil-Malherbe H. Biochem. J. [illegible] 1938. (15) Warburg, O. Biochem. Ztschr. [illegible] 1925. (16) Krebs H. A. and Kubowitz, F. Biochem. Ztschr. [illegible] 1927 (17) Warburg, O. Biochem. Ztschr. [illegible] 1924

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152. OXYGEN CONSUMPTION NERVE TISSUE, INCLUDING RETINA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	14 15 ABC	11a	25 ABC	11a,29a
2 ABC	2b	16 ABC	3a,11a,12a,13a,14a, 15a,16a,17a	28 ABC	27a
3 ABC	2ab 5a			29 ABD	26a
4 ABC	4a	17 ABC	18a	30 ABC	27b
5 ABC	20a	18 ABC	19a	31 ABD	26a
6 12 ABC	7a	19,27 ABC	20a	32 ABC	8a,17a,24a,26a,27a, 27b
7 ABC	8a	20,26 ABC	21a		
8 ABC	7aa	21 ABD	22a	33 ABC	5a
9,10,11 ABC	6a	22 ABD	3a	34 ABD	15a
13 ABC	8a,9aa,10aa	25,26 ABC	11a		

Contributors: ( ) Barker S. B. (b) Elliott, K. A. C ( ) Quastel, J. H. and Scholefield, P. G.

References (1) Warburg, O. and Rabowitz F. Biochem. Ztschr. 189:242, 1927 (2) Elliott, K. A. C. J. Neurophysiol. 11:473, 1948. (3) Craig, F. N. and Beecher H. K. J. Neurophysiol. 6:135, 1943 (4) Himwich, H. E., and Fazekas J. F. Am. J. Physiol. 132:454, 1941. (5) Ogata, T. Jap. J. Med. Sci. Trans. III Biophysics 2:131, 1952. (6) Flexner J. B., Flexner L. B., and Straus, W. L. J. J. Cell. Compar. Physiol. 18:355 1941. (7) Nixon, F. L., and Lalair L. F. Biochem. J. 30:1519 1936. (8) Dickens F. and Greville, G. D. Biochem. J. 27:1838 1933 (9) Akins, T., Tohoku J. Exper. Med. 13:426 1929. (10) Krebs, H. A., and Rosenhagen, H., Ztschr. f. d. ges. Neurol. u. Psychiat. 134:643, 1931. (11) Chesler, A. and Himwich, H. E. Am. J. Physiol. 141:513 1944 (12) Dickens F. and Greville G. D. Biochem. J. 27:832, 1933 (13) Dickens F. and Simer F. Biochem. J. 24:1301, 1930. (14) Elliott K. A. C. Greig, M. E. and Benoy M. P. Biochem. J. 31:1003, 1937 (15) Loebell, R. O., Biochem. Ztschr. 161:219 1925. (16) Meyerhof O. and Lohmann, K., Biochem. Ztschr. 171:381,421, 1926. (17) Warburg, O. Posener K. and Negelein, E. Biochem. Ztschr. 152:309, 1924 (18) Fujita, A. Biochem. Ztschr. 197:175, 1928. (19) Tobias, J. M. Clark, D. B. and Gerard, R. W., Fed. Proc. 1:85 1942 (20) Nelson E. E. Biochem. J. 26:2005 1932. (21) Pearce J. and Gerard, R. W. Am. J. Physiol. 136:49, 1942. (22) Roberts E. and Rock, M. (unpublished) (23) Mallet C. Weinstein, P. and Jáuy J. Biochem. Ztschr. 247 146, 1932 (24) Negelein, E. Biochem. Ztschr. 165:122 1925. (25) Greig, M. E. Munro M. P. and Elliott, K. A. C. Biochem. J. 33:443, 1939 (26) Laser H. Biochem. J. 31:1671, 1937 (27) Robbie W. A. and Leinfelder P. J. Am. J. Ophth. 32:1006, 1949 (28) Weil-Malherbe, H. Biochem. J. 32:2257 1938. (29) Elliott, K. A. C. and Baker Z. Biochem. J. 29:2433 1935

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153. OXYGEN CONSUMPTION NERVE TISSUE: DOG

Data Coordinates and Footnotes	Contributors and References
Footnote	2a 3a 4a,
1-7 ABCDE	1b,2a
Fn 2	3a,4a

Contributors (a) Elliott K. A. C. (b) Himwich H. E.

References (1) Himwich H. E. Brain metabolism and cerebral disorders Baltimore: Williams & Wilkins Co. 1951, Table 17 (2) Himwich H. E. and Fazekas J. F. Am. J. Physiol. 132:454 1941. (3) Elliott K. A. C. and Henderson, N. J. Neurophysiol. 11:473 1948 (4) Krebs H. A. Biochem. et Biophys. Acta. 4:249 1950.

Reviewers Barker S. B.; Craig F. N.; Elliott K. A. C.; Fuhrman, F. A.; Himwich, H. E.; Jandorf B. J.; Krebs H. A.; Schaefer A. E.; Tyler D. B.

154. ANAEROBIC GLYCOLYSIS NERVE TISSUE: CAT DOG

Data Coordinates and Footnotes	Contributors and References
Fn 1	b
Fn 2	a
1 7 ABCDEFGH	1b

Contributors: ( ) Elliott K. A. C. (b) Himwich, H. E.

References: (1) Chesler A. and Himwich, H. E. Am. J. Physiol. 142 544 1944

Reviewers Craig, F. N.; Elliott K. A. C.; Fuhrman, F.; Himwich H. E.; Lardy H. A.; Sonnerman F. N.; Tyler D. B.

155. OXYGEN CONSUMPTION: REPRODUCTIVE TISSUES INCLUDING GONADS AND SPERM

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 3 ABC	1a	12 ABC	6a	22 ABC	8ad
4,24 ABC	2a	13 14 17 18 ABC	7a	23 ABC	9a,10a 11a,12a,15b 13a 14a 15a
5,6,26 ABC	3a	15 ABC	18c		
7 10 ABC	4a	16,19,20 ABC	17	25,27,28 ABC	16a
11 ABC	5a	21 ABC	2ad		

Contributors: (a) Barker S. B. (b) Elliott, K.A.C (c) Jandorf B. J (d) Quastel J H and Scholefield, P G

References: (1) Polley [illegible] J and French, T H Biochem. J 45 270 1949 (2) Fujita, A Biochem. Ztschr 197:175 1928. (3) Barker, S. B, and Schwartz H. S (unpublished) (4) Levey H. A and Songe, C N (unpublished) (5) MacLeod, J Am. J Physiol 138:512 1943 (6) Lardy H A and Phillips P H J Biol. Chem. 148:333 1943 (7) Dodson, E Biochem. Ztschr 271:436 1933 (8) Ishii, T Tohoku J Exper Med 13:426 1929 (9) Barker S B and Klitgaard, H. M. Am. J Physiol. 170:81, 1952 (10) Dickens F and Greville G D Biochem J 27:832, 1933 (11) Dickens F., and Simer, F Biochem. J 35:7 1941 (12) Elson, H L and Leloir L. F Biochem J 30:2319 1936 (13) Elliott K. A. C Greig M. E and Benoy, M P, Biochem J 31 1003 1937 (14) Warburg, O Posener K. and Negelein, E. Biochem. Ztschr, 152:309, 1924 (15) Weil-Malherbe H. Biochem. J 32:2257 1938. (16) Roberts S and Songe, C. N. J Biol. Chem. (in press) (17) Lardy H. A. and Phillips P H. Am. J Physiol. 138:741 1943 (18) Lardy H. A. Hansen, R. G. and Phillips P H. Arch Biochem. 6:41 1945.

Reviewers: Barker S. B. Dickens F Elliott K. A. C. Jandorf B. J Krebs H. A. MacLeod J Quastel J H.; Scholefield P G.

156. OXYGEN CONSUMPTION: REPRODUCTIVE TISSUES PLACENTA MEMBRANES AND EMBRYO

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 ABC	1a	7 8 ABC	6a	12 ABC	4a,10a
3 15,16,18 ABC	2a	9 ABC	6ab	13 ABC	11ab
4 5 ABC	3a	10 ABC	4a	14 ABC	11a
6 ABC	4a,5a,6a,7a	11 ABC	9ab	17 ABC	12a

Contributors: ( ) Barker S. B. (b) Quastel, J H and Scholefield, P G

References (1) Laser H. Biochem. J 31 1671, 1937 (2) Bell W B. Brooks, J and Jowett, M J Cancer Res 12:369 1928. (3) Emmanuilov, [illegible] Biochem. Ztschr 193 319 1928. (4) Dickens F, and Greville, G D. Biochem. J 27:832, 1933 (5) Brieg, M. E. Moore, M. F and Elliott K. A. C Biochem. J 33 443, 1939 (6) Needham, J Proc R. Soc. B, 110:46 1932 (7) Warburg, O. Posener K. and Negelein, E Biochem. Ztschr, 152 309 1924 (8) Weil-Malherbe H. Biochem. J 32:2257 1938. (9) Negelein, E., Biochem. Ztschr 165 122, 1925 (10) Kleiber M., Cole H. H and Smith, A. H. J Cell. Compar Physiol. 22:167 1943. (11) Fujita A. Biochem. Ztschr 197 175 1928. (12) Murphy J B. and Hawkins J A. J Gen. Physiol. 8:115 1925.

Reviewers: Barker S. B.; Dickens F; Elliott K. A. C; Flexner L. B.; Jandorf B. J; Kleiber M.; Krebs H. A.; MacLeod J; Moore R. O.; Quastel J H.; Scholefield P G

157 CORRELATION OF OXYGEN CONSUMPTION WITH BODY SIZE: INVERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-W	13b	11 B-D & Fn 2	1a	20 B-D & Fn 2 7 8	11a
2 B-W & Fn 2	1a	12 B-D & Fn 2	6a	23 B-D & Fn 3	7a
3 B-D & Fn 3	8a	13 B-W & Fn 2	5a	24 B-D & Fn 3	3a
4 B-D & Fn 4	3a	14 B-W & Fn 2	1a	25 B-W & Fn 3	9a
5 B-D & Fn 3	4a	15 B-D & Fn 3	13a	26 B-D & Fn 3	8a
7 B-W & Fn 4 5 6	1a	16 B-W & Fn 3	13a	27 B-W & Fn 4	9a
9 B-W & Fn 4	2a	17 B-W & Fn 3	3a	28 B-W & Fn 4	1a
10 B-D & Fn 2	6a	18,19 B-W & Fn 2 3	9a	29 B-W & Fn 4	10a

Contributors ( ) von Bertalanffy L. (b) MacFadyen, A.

References (1) von Bertalanffy L. and Muller I Riv Biol. 35:48, 1943 (2) Kruger, F Ztschr wiss Zool. 152:547 1940 (3) Muller I. Biol. Zbl. 63 446, 1943 (4) Kruger F Ztschr Vergl Physiol 34 1, 1952 (5) Krywienczyk, J Ztschr Vergl. Physiol. 34 6, 1952 (6) Puhser, K. and Kruger F, Ztschr Vergl. Physiol. 33 14 1951 (7) Jancarik, A. Pub Fac Sci. Univ Masaryk 11 305, 1948 (8) von Bertalanffy L. and Krywienczyk, J Am. Natur 87 107 1953 (9) Will, A. Ztschr Vergl. Physiol. 34:20 1952. (10) Muller I. Ztschr Vergl. Physiol. 30:139, 1943 (11) Weymouth, F W et al. Physiol Zool. 17:50, 1944 (12) Zeuthen E. Compt rend. Lab Carlsberg 26 399 1943 (13) Krywienczyk, J Ztschr Vergl. Physiol 34:16, 1952

Reviewers Fry F E. J; Krüger F; MacFadyen A.; von Bertalanffy L.; Weymouth F W; Zeuthen, E.

132. OXYGEN CONSUMPTION, NERVE TISSUE: [illegible]

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	14 15 ABC	11a	25 ABC	11a,28a
2 ABC	2ab	16 ABC	8a,11a,12a,13a,14a, 15a,16a,17a	28 ABC	25a
3 ABC	2ab,3a			29 ABC	24a
4 ABC	4a	17 ABC	18a	30 ABC	27b
5 ABC	28a	18 ABC	19a	31 ABC	26a
6 12 ABC	7a	19,27 ABC	20a	32 ABC	8a,17a,24a,26a,27a, 29b
7 ABC	1a	20,26 ABC	21a		
8 ABC	5ae	21 ABC	22a	33 ABC	5a
9,10,11 ABC	6a	22 ABC	5a	34 ABC	15a
13 ABC	8a,9ae,10ae	23,24 ABC	11a		

Contributors: ( ) Barker S. B (b) Elliott, K. A. C ( ) Quastel, J. H. and Schoolefield, P. G

References: (1) Warburg, O and Schwartz F Biochem. Ztschr 189:242, 1927 (2) Elliott, K. A. C J Neurophysiol. 11:473 1948. (3) Craig, F N. and Beecher H. K. J Neurophysiol. 6:135, 1943 (4) Himwich, H. E., and Fazekas J F Am. J Physiol. 132:454 1941. (5) Ogata, T Jap J Med. Sci Trans III Biophysics 1:131, 1930 (6) Flexner J B, Flexner L. B., and Strauss, W L. Jr J Cell. Compar Physiol. 18:355 1941. (7) [illegible], R. L. and [illegible] L. F Biochem. J 30:319 1936 (8) Dickens F and Greville G. D. Biochem. J 27:832, 1933 (9) [illegible], T, [illegible] J Exper Med. 13:[illegible] 1929 (10) Krebs H. A. and [illegible], E., Biochem Z [illegible] Neurol. u. Psychiat. 133:[illegible], 1931. (11) Chesler, A. and Himwich, H. E. Am. J Physiol. 141:513 1944 (12) Dickens F and Greville G D. Biochem. J 27:1[illegible] 1933 (13) Dickens F and Simer F Biochem. J 24:1301, 1930. (14) Elliott K. A. C Greig, M. E. and Benoy M. P Biochem. J 31:1003 1937 (15) Loebell, R. O, Biochem. Ztschr 161:219, 1925 (16) Meyerhof O. and Lohmann, K., Biochem. Ztschr 171:381,421, 1926. (17) Warburg, O. Posener K. and Negelein, E Biochem. Ztschr 152:309, 1924 (18) Fujita, A. Biochem. Ztschr 197 175, 1928. (19) Tobias J M. Clark, P R. and Gerard, R. W Fed. Proc 1 85 1942 (20) Holmes E. G. Biochem. J 26:2005, 1932. (21) Fearon J., and Gerard, R. W Am. J Physiol. 136:149, 1942. (22) Roberts E. and Beck, M. (unpublished) (23) Mellet C Weinstein, P and Jay J, Biochem. Ztschr 247:146, 1932 (24) Negelein, E., Biochem. Ztschr 165 122 1925 (25) Ortiz, N. S Moore M. P and Elliott, K A C. Biochem. J 33:443, 1939 (26) Laser H Biochem. J 31 1671, 1937 (27) Robbie W A. and Leinfelder P J Am. J Ophth. 32:[illegible], 1949 (28) Weil-Malherbe H. Biochem. J 32:2257 1938. (29) Elliott K. A. C. and Baker Z. Biochem. J 29:2433 1935

Reviewers: Barker S B. Dickens F Elliott K. A. C Jowett B. J Krebs H. A. Quastel J H.; Schoolefield P G.

133 OXYGEN CONSUMPTION, NERVE TISSUE: [illegible]

Data Coordinates and Footnotes	Contributors and References
Brain [illegible]	2a,3a,4a
1 7 [illegible]	1b,2a
Fn 2	3a 4a

Contributors: (a) Elliott K. A. C. (b) Himwich, H. E.

References: (1) Himwich, H. E. Brain metabolism and cerebral disorders, Baltimore: Williams & Wilkins Co 1951, Table 17 (2) Himwich, H. E. and Fazekas J F Am. J Physiol. 132:454 1941. (3) Elliott K. A. C and Henderson, N J Neurophysiol. 11 473 1948 (4) Krebs H. A. Biochem. et Biophys Acta. 4 249 1950

Reviewers: Barker S. B.; Craig, F N.; Elliott K. A. C ; Fuhrman, F A.; Himwich H. E.; Jowett B. J ; Krebs H. A.; Schaefer A. E.; Tyler D. B.

134 ANAEROBIC GLYCOLYSIS, NERVE TISSUE: CAT DOG

Data Coordinates and Footnotes	Contributors and References
Fn 1	b
Fn 8	
1 7 [illegible]	1b

Contributors: (a) Elliott K. A. C. (b) Himwich H. E.

References: (1) Chesler A. and Himwich, H. E. Am. J Physiol. 141:513 1944.

Reviewers: Craig, F N.; Elliott, K. A. C.; Fuhrman F.; Himwich, H. E.; Lardy H. A.; [illegible] F H.; Tyler D. B.

155. OXYGEN CONSUMPTION: REPRODUCTIVE TISSUES INCLUDING GONADS AND SPERM

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2,3 ABC	1a	12 ABC	6a	22 ABC	8ad
4,24 ABC	2a	13 14 17 18 ABC	7a	23 ABC	9a,10a 11a,12a,13b 13a 14a,15a
5 6,26 ABC	3a	15 ABC	18a		
7-10 ABC	4a	16 19,20 ABC	17a	25,27,28 ABC	16a
11 ABC	5a	21 ABC	2ad		

Contributors: (a) Barker S B (b) Elliott K.A.C (c) Jandorf B. J (d) Quastel J H. and Scholefield, P G

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Reviewers: Barker S. B. Dickens F Elliott K. A. C. Jandorf B. J Krebs H. A. MacLeod J Quastel J H.; Scholefield P G

156. OXYGEN CONSUMPTION REPRODUCTIVE TISSUES PLACENTA, MEMBRANES AND EMBRYO

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 ABC	1a	7 8 ABC	6a	12 ABC	4a,10a
3,15,16,18 ABC	2a	9 ABC	8ab	13 ABC	11ab
4 5 ABC	5a	10 ABC	4a	14 ABC	11a
6 ABC	4a,5a,6a,7a	11 ABC	9ab	17 ABC	12a

Contributors: (a) Barker S B. (b) Quastel J H. and Scholefield, P G

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157 CORRELATION OF OXYGEN CONSUMPTION WITH BODY SIZE: INVERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-H	12b	11 B-D & Fn 2	1a	20 B-D & Fn 2 7 8	11a
2 B-E & Fn 2	1a	12 B-D & Fn 2	6a	23 B-D & Fn 3	7a
3 B-D & Fn 3	8a	13 B-E & Fn 2	5a	24 B-D & Fn 3	3a
4 B-D & Fn 4	3a	14 B-E & Fn 2	1a	25 B-E & Fn 3	9a
5 B-D & Fn 3	4a	15 B-D & Fn 3	13a	26 B-D & Fn 3	8a
7 B-E & Fn 4 5 6	1a	16 B-E & Fn 3	13a	27 B-E & Fn 4	9a
9 B-E & Fn 4	2a	17 B-E & Fn 3	5a	28 B-E & Fn 4	1a
10 B-D & Fn 2	6a	18,19 B-E & Fn 2,3	9a	29 B-E & Fn 4	10a

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Reviewers: Fry F E. J; Krüger F; MacFadyen, A.; von Bertalanffy L.; Weymouth F W; Zeuthen, E.

138. OXYGEN CONSUMPTION: INVERTEBRATE EMBRYOS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 RCD	1a	14,15,16 RCD	7a	26 RCD	1a
2-4 RCD	8a	17 RCD	1a	27 RCD	9a
5 RCD	3a	18-22 RCD	7a	28 RCD	10a
6,7 RCD	4a	23 RCD	6a	29 RCD	10a,11a
8-10 RCD	5a	24 RCD	1a	30,31 RCD	12a
11 RCD	6a	25 RCD	7a	32 RCD	7a
12,13 RCD	1a				

Contributors ( ) Silverman, M.

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Reviewers: Borelli G. D.; Paretsky D.; Pedlow J. T.; Silverman, M.; von Brand, T.

139. OXYGEN CONSUMPTION: PARASITIC PROTOZOA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-3 RCD	1b	9 RCD	3a,9b	18 RCD	3a,12b
4 RCD	2b 3b,4b	10 RCD	3a 4a,10b	19 RCD	9b
5 RCD	3a,b 4b	11 14 RCD	9b	20 RCD	3a,9b
6 RCD	2b,3b,4b,5b	15 RCD	3a,11b	21 RCD	13b
7 RCD	3a	16 RCD	9a	22 RCD	14b
8 RCD	7b,8b	17 RCD	3a,9b	23-27 RCD	15b

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References: (1) Lwoff A. Zentr. Bakt. Parasitenk. Abt. I. Orig. 130:498 1934. (2) Adler S., and Ashbel R. Arch. zool. Ital. [illegible] 1934. (3) von Brand, T. and Johnson, E. M. J. Cellular Comp. Physiol. [illegible] 1947. (4) Cheng, S. L. J. Infect. Dis. [illegible]:109 1948. (5) Fulton, J. D. and Joyner, L. P. Trans. Roy. Soc. Trop. Med. Hyg. [illegible], 1949. (6) [illegible] L. Smythe C. V. and Pedlow J. T. J. Biol. Chem. [illegible] 1938. (7) Moulder J. W. Science 106:168 1947. (8) Moulder, J. W. J. Infect. Dis. [illegible] 1948. (9) von Brand T., Tobie, E. J. and Mehlman B. J. Cellular Comp. Physiol. [illegible], 1950. (10) von Brand, T., Johnson, E. M. and Rees C. W. J. Gen. Physiol. 30:163 1946. (11) Harvey, S. C. J. Biol. Chem. [illegible], 1949. (12) Christophers S. R. and Fulton, J. D. Ann. Trop. Med. Parasitol. [illegible], 1938. (13) [illegible], L. Zentr. Bakt. Parasitenk. Abt. I. Orig. [illegible], 1936. (14) Williams, [illegible] L. and [illegible] G. Naturwissenschaften [illegible] 1942. (15) Meier J. and Coggeshall L. T. J. Infect. Dis. [illegible]:87 1941.

Reviewers: Cheng, S. L.; Borelli G. D.; Paretsky D.; Pedlow J. T.; Silverman M.; von Brand T.

140. RATES OF RESPIRATION: LEAVES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 RCD	1a	8 RD	7a	17 RCD	16a
Fn 2	2a	9 RC	4d	18 RD	17b
2 RCD	3d	10 RC	10b	19 RC	18b
3 RD	4a	Fn 7	11a	20 RC	4b
4 RD & Fn 3	3abc	11 RD & Fn 8	12a	21 RD	19b
5 RD & Fn 4	21a	12 RD	9bc	22 RD	20a
6 RC	7	13 RC & Fn 9	7a	23 RC	6b
7 RD	9a	14 RCD & Fn 10	13a	1,2,14,17 R	Calc. fr col. C, D & Fn 1
Fn 6	6b	15 RD	14b		
		16 RD	15a		

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References: (1) Yemm E. W. Proc. Roy. Soc. Lond. B117 504 1935. (2) Phillips, J. W. Am. J. Bot. [illegible], 1947. (3) Maige G. Ann. Sci. Nat. Bot. (IX) 14:1 1911. (4) Richards, F. M. Ann. Bot. 10:531 1896. (5) Marsh P. and Goddard D. R. Am. J. Bot. 26:724 1939. (6) [illegible] L. J. New Phytol. [illegible], 1939. (7) [illegible] (unpublished). (8) [illegible], Bot. Gaz. [illegible] 1911. (9) Beatty A. V. Am. J. Bot. [illegible] 1946. (10) McKenzie K. A. Proc. Am. Soc. Hort. Sci. [illegible] 1931. (11) Rose, D. H. et al. U. S. Dept. Agr. Circ. [illegible] 1950. (12) [illegible] J. Mo. Agr. Exp. Sta. Tech. Bull. [illegible] 1905. (13) Aubert, E., Rev. Gen. de Bot. 4:[illegible] 1892. (14) Maige M. Rev. Gen. Bot. [illegible] 1909. (15) Laing H. E. Am. J. Bot. [illegible], 1940. (16) [illegible] J. and Williams [illegible] Arch. Biochem. [illegible] 1946. (17) [illegible], Plant Physiol. 11:[illegible], 1936. (18) Gustafson, F. G., Am. J. Bot. [illegible], 1930. (19) [illegible] Jahrb. Wiss. Bot. [illegible] 1939. (20) Allen, P. J. and Goddard, D. R. Am. J. Bot. [illegible] 1938. (21) Girton, R. E. (unpublished)

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141. RATES OF RESPIRATION: ROOTS, RHIZOMES, TUBERS, BULBS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 RC & Fa 2 3	1a	6 RC	3b	Fa 10	7a
2 RCD	8a	7,8 RC & Fa 7,8	1a	Fa 11	3b
Fa 4 5	1a	9 B D & Fa 9		14 RC & Fa 12	1a
3 B D & Fa 6	9a	10 RC	8a	15 B D & Fa 13	4b
4 B D	10b	11 RC	8a	8,13 E	Calc. fr Col. C D & Fa 1
5 RC & Fa 2	11b	12 RC	8a		
		13 RCD	4a	3 E	12d

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144. RATES OF RESPIRATION: SEEDS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D	1b	6 B D & Fa 4	3b	10 B D	1b
2 RCD	8b	7 RC & Fa 5	3b	11 C & Fa 3	7a
Fa 2	3b	8 RC	10b	12 RC & Fa 5	3b
3 RC & Fa 3	4a	Fa 6	6a	13 RC & Fa 7	6a
4,5 B D	1b	9 B D	1b	14 RC & Fa 5	3b
				Fa 8,9	9a

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145. RATES OF RESPIRATION: FRUITS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D	1b	5 RCD & F 5	3a	11 B D	10a
1 C & Fa 2	1a	6 B D	6a	11 C & Fa 7	9a
2 RCD	8d	7 RC	7d	12 RCD & Fa 8	11a
3 D	8d	Fa 6	2a	1,2 3,11,12 E	Calc fr Col C,D & Fa 1
3 B D & Fa 3	7b	8 B D	4a	4,10 E	4a
Fa 4	3a	9 RC	6b		
4 RC	4b	10 RC	4b		

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144 RATES OF RESPIRATION MOSSES FERNS

Data Coordinates and Footnote	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 2 4 BD	1a	8 BC	5a	14,15 BCD & Fn 7	
3 BD & Fn 2	2a	9,10 BD & Fn 6 7 8	6a	11,12	7b
5 6 CD & Fn 3 4	3b	11,12 BCD & Fn 7	7b	5,6,11,12,14,15 E	Calc fr col. C D & Fn 1
7 BC	4a	9,10	7b		
		13 BD	5a		

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145. RATES OF RESPIRATION FUNGI LICHENS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD & Fn 3	9b	10,11 BCD	9b	17 BC & Fn 3	9a
Fn 4	9a	F 11,12	7bc	18 B D & Fn 5	13a
2 BCD & Fn 5	1b	12 B D & Fn 13	6a	19 B D	9a
3 B D & Fn 5	10a	13 BD & Fn 5	11a	20 B D & F	8a
4 5 B D & Fn 6 7	8a	14,15 B D & Fn 14		21 BCD	14b
6 B D & F 3	9a	15	7b	22 BD & Fn 5	15a
7 B D & Fn 8	5a	16 B D & Fn 6	12a	1,2,10 EF E	Calc. fr col. B C & Fn 1
8 9 B D & F 9,10	4b			14 B	16a

Contributors ( ) Klein, R. M. (b) Lyon C J ( ) Thomas M.

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Reviewers Blinks L. R.; Fidler J C; Gaffron H.; Girton R. E.; Gustafson F G.; Hansen E.; Lyon, C J; Myers J; Robertson, R. N.; Smock, R. M.; Thomas M.; Voth, P D.

146 RATES OF RESPIRATION ALGAE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D	6a	6 B D & Fn 4	8a	12,14 D & Fn 7	3a
2 B D	7	7 B D & Fn 2	2b	13 BCD	4b
3 BCD & Fn 2 3	1b	8 9 BCD & Fn 5 6	3b	15,16 B D & Fn 7	3a
4 B D	5a	10 BCD	4b	17 BCD	4b
5 B D	7	11 B D	7a	3,8 9,10,15,17 E	Calc fr col C,D & Fn 1

Contributors (a) Klein R. M. (b) Lyon, C J

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/1/ Cramer M and Myers J Plant Physiol 24 255 1949 /2/ Gaffron, H J Gen. Physiol 28 299 1945 /3/ Pal N L. New Phytol 33 241 1934 /4/ Hoffman C Jahr Wiss Bot 71 214 1929 /5/ Stocker O Tab Biol 5 663 1929 /6/ Webster G C and Frenkel A. W, Plant Physiol 28 63 1953 /7/ Watanabe A. Acta Phytochim. 6 315 1932 /8/ Rees E Am J Bot. 23 458 1936.

Reviewers Blinks L. R.; Fidler J C.; Gaffron, H.; Girton R. E.; Gustafson F G; Hansen E.; Lyon C J; Myers J; Robertson, R. N.; Smock, R. M.; Thomas M.; Voth P D.

147 OXYGEN CONSUMPTION BACTERIAL SUSPENSIONS

Data Coordinates and Footnotes	Contributors and References	Data Coordinate and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD	1b	9 BCD	9b	27 BCD	16a
2 BCD	2b,3b	10 BCD	10b	28 BCD	17b
3 4 BCD	4b	11-15 BCD	11b	29 BCD	18b
5 BCD	5b	16-23 BCD	12b	30 31 BCD	19b
6 BCD	6a	24 BCD	13b	Fn 1,2 3	19a
7 BCD	7b	25 BCD	14b	32 33 BCD	9b
8 BCD	7b,8b	26 BCD	15b	34 BCD	20b

Contributors: (a) Fuller J T (b) Silverman, M.

References (1) Meyerhof O. and Burk D., Z. Physik Chem. A 139:117 1928. (2) Gill [illegible] J Bact. [illegible], 1950. (3) Gill [illegible] and [illegible] J Bact 61 [illegible] 1951. (4) Pickering [illegible] and [illegible] J Bact. 63:[illegible] 1952. (5) [illegible] and [illegible] J Bact [illegible] 1952. (6) Cronk [illegible] J Bact 63:[illegible] 1952. (7) Levine [illegible] and Krampitz L. O. J Bact. 63:[illegible] 1952. (8) Krebs H. A. Biochem. J [illegible] 1951. (9) Stein [illegible], and Frazier W. C. J Bact. [illegible] 1961. (10) Chang, [illegible], Silverman, M. and [illegible] J. C. J Bact. 63 [illegible] 1952. (11) [illegible] and Fabian F. W. J Bact. [illegible] 1962. (12) [illegible] and [illegible] Biochem. J [illegible] 1963. (13) [illegible], Smith, [illegible], and [illegible] J Bact. [illegible] 1950. (14) Bernheim F., and Bernheim, M. L. C. J Bact. [illegible], 1963. (15) [illegible] and [illegible] C. L. J Bact. 65:[illegible] 1958. (16) [illegible] and [illegible] J Bact. 61:[illegible], 1951. (17) O'Kane D J J Bact. [illegible] 1950. (18) [illegible] and [illegible] J Bact. [illegible] 1963. (19) [illegible] and [illegible] J Bact [illegible] 1962. (20) [illegible] and [illegible] J Bact. [illegible] 1951.

Reviewers: Borelli [illegible]; [illegible]; Fuller J T; Silverman M.; von Brand T

148. BASAL METABOLISM: MAN

All values: (a) Boothby W M. from smoothed curve based on references 1, 2 3. All ranges: (b) DuBois E F from coefficients of variation for data from references 2 3, 4 5, 6

References: (1) Boothby W M. Berkson, J and Dunn, H. L. Am. J Physiol 116:468, 1936. (2) Robertson, J D and Reid, D. D Lancet 1:940, 1952 (3) Harris J A, and Benedict, F G, Carnegie Inst of Washington Publ. 279 1919 (4) Lewis R. C Kinsman, G. M. and Iliff A. Am. J Dis Child. 53:348, 1937 (5) Lewis, R. C. Duval, A. M. and Iliff A. J Pediatrics [illegible] 1943 (6) Berkson, J and Boothby W M. Am. J Physiol. 121:669 1938.

Reviewers: Berkson, J; Boothby W M.; Carpenter T M.; DuBois E. F

149 COMPARISON OF STANDARDS OF BASAL METABOLISM: MAN

Contributor: (a) DuBois E. F

References: (1) Col. B, table 148 of this publication. (2) Col. C, Fleisch, A. Helvetica Med. Acta, 18:23 1951. (3) Col. D Robertson, J D, and Reid, D D Lancet, 1:940 1952 (4) Col E, Lewis, R. C Duval, A. M., and Iliff A. J Pediatrics 23 1, 1943 (5) Col. F Boothby W M. Berkson, J, and Dunn, H L. Am. J Physiol. 116:468, 1936 Estimate of ordinary range based on coefficient of variation of 6 % calculated by contributor from data in references 3 4 and (6) Berkson, J, and Boothby W M. Am. J Physiol. 121:669, 1938. (7) Harris J A., and Benedict F G. Carnegie Inst of Washington Publ. 279, 1919. (8) Lewis R. C Kinsman, G M. and Iliff A. Am. J Dis. Child. 53:348, 1937

Reviewers: Berkson, J; Boothby W M.; Carpenter T M.; DuBois E. F; Iliff A.

150. BASAL METABOLISM: [illegible]

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 BC	27a	7 DCF	9a,10a	14 DCF	6a
1 BCF	14a	8 DCF	12a	15 BC	22a
2 DCF	14a,15a	9 DCF	7a	15 DCF	2a
3 B-F	6a	10 B-F	3a	16 BC	26a
4 BC	23a	11 BC	23a	16 DCF	11a
4 DCF	19a,20a	11 DCF	3a	Fn 1	Quoted by from 3 4,21,22,23,24,25, 26,27,28,29
5 BC	Calc fr 23 & 24	12 BC	21a		
5 DCF	4a by a	12 DCF	2a		
6-9 BC	Calc. by a	13,14 BC	28a	Fn 3	a
6 DCF	13a	13 DCF	16a,17a,18a		

Contributor: (a) Mitchell, H. H.

References: (1) [illegible], J R., and Van Dyke H. B. J Biol. Chem. [illegible], 19[illegible] (2) Breirem, K. L. and Mitchell, H. H. J Nutrition [illegible], 1947 (3) Kibler H. H. Brody S. and Worstell, D., J Nutrition 33 331, 1947 (4) Mitchell, H. H. and Haines W T J Agr Res 34:549 [illegible] 1927 (5) Ashworth, U. J Nutrition [illegible] 1935. (6) Lee R. C. J Nutrition 18:489, 1939 (7) Benedict, F G. and Lee R. C., Carnegie Inst. Wash. Publ. 489 1937 (8) Bruhn, J M. Am. J Physiol. 110:477 1934 (9) Galvao, P E. Am. J Physiol. 148:478, 1947. (10) [illegible] K. K. and [illegible], A. K., Am. J Physiol. [illegible] 1946. (11) Blaxter K. L. J Agr Sci. 38:207 1948. (12) Ritzman, E. G. Washburn, L. E. and Benedict F G. N H Agr Exp. Sta. Tech. Bull 66, 1936 (13) Bruhn, J M. and Benedict, F G Proc Am. Acad. Arts and Sci 71:[illegible] 1936. (14) Harris, J A., and Benedict, F G Carnegie Inst Wash. Publ. 279 1919. (15) McCrery, J , Lamb M. W and Brownsett, F D. J Nutrition [illegible] 1943 (16) Capstick, J W and Wood, T B. J Agr Sci. 12:257 1922 (17) Deighton, T J Agr Sci 19:140, 1929. (18) Breirem, K. Tierernährung, 8:463 1936. (19) Forbes E B. et al. J Agr Res 33 591, 1926 (20) Ibid. 34:1003, 1931. (21) Boots D B Pflüger's Arch. ges Physiol. [illegible], 1933 (22) Lee, R. C. Am. J Physiol. [illegible], 1929. (23) Rubner, [illegible], Z Biol. 15:[illegible], 1879. (24) Mitchell, H. H. Card, L E and Hamilton, T S Ill. Agr Exp Sta. Bull. 278, 1926. (25) Lee, R. C. and [illegible], L., Am. J Physiol. [illegible], 1933 (26) Mitchell, H. H., Ill. Agr Exp. Sta. Ann. Rept. 1927 p175. (27) DuBois, D. and DuBois E. F , Arch. Int. Med. 17 863 1916 (28) Brody S. Comfort J E and Matthews J S. Mo. Agr Exp. Sta. Res Bull. 115, 1928. (29) Moulton, C R. J Biol. Chem. 24:299, 1916.

Reviewers: Brody S.; Bruhn, J M.; Forbes E. B.; Kibler H. H.; [illegible] K. K.; Lambooy [illegible]; Lee R. C.; Mitchell H. H.; [illegible] K.; Ritzman, E. G.; Swift R. W

151. BASAL AND RESTING ENERGY METABOLISM: BEEF CATTLE

References: Values calculated and adapted from Brody S Comfort, J E., Kibler H. H. and Worstell, D. M. Mo Agr Exp. Sta. Res Bull. 406 and 115; and contributed by Brody S

Reviewers: Brody S.; Colovos, N F ; Mitchell, H. H.; Ritzman, E. G ; Winchester C F

152. RESTING ENERGY METABOLISM: DAIRY CATTLE

References: Values calculated and adapted from the data in Brody S., Kibler H. H. and Ragsdale A. C. Mo Agr Exp Sta. Res Bull. 373 and 393; and contributed by Brody S

Reviewers: Brody S.; Colovos N F ; Kibler H. H.; Mitchell, H. H.; Ritzman, E. G.; Winchester C F

153 RESTING ENERGY METABOLISM: GOATS

References: Contributed and adapted from Brody S. Res Bull. 491, Uni of Missouri, Agr Exp Sta. 1952.

Reviewers: Brody S.; Carpenter T M.; Colovos, N F ; Mitchell, H. H.; Winchester C F

154 BASAL AND RESTING ENERGY METABOLISM: [illegible]

References: Values calculated and adapted from the data in Kibler H. H., and Brody S. J Nutrition 33:331, 1947 Reprint contributed by Brody S. and tabular data contributed by Kibler H. H.

Reviewers: Brody S.; Colovos, N F ; Kibler H. H.; Mitchell, H. H.; Winchester C F

155 RESTING ENERGY METABOLISM: HORSES

References: Values calculated and adapted from the data in Brody S, Kibler H H and Trowbridge E. A Mo Agr Exp Sta. Res Bull 368, and contributed by Brody S

Reviewers: Brody S ; Colovos N F ; Kibler H H ; Mitchell H H ; Winchester C F

156 RESTING ENERGY METABOLISM: MULES

References: Values calculated and adapted from the data in Kibler H H and Brody S Mo Agr Exp Sta Res Bull 453 Data contributed by Brody S Reprint from Brody S Kibler H H and Trowbridge E A Mo Agr Exp Sta Res Bull 368, 1943

Reviewers: Brody S ; Kibler H H.; Mitchell H. H.; Winchester C F

157 BASAL AND RESTING ENERGY METABOLISM: RATS

References: Values calculated and adapted from Kibler H. H and Brody S J Nutrition 24 461, 1942 Reprint contributed by Brody S and tabular data contributed by Kibler H. H

Reviewers: Brody S ; Colovos N F ; Kibler H. H ; Mitchell H. H ; Winchester C F

158. RESTING AND FASTING ENERGY METABOLISM: SWINE

References: Values calculated and adapted from the data in Brody S and Kibler H H. Mo Agr Exp Sta. Res Bull 380 Data contributed by Brody S

Reviewers Brody S ; Colovos N F ; Kibler H. H ; Mitchell H. H.; Winchester C F

159 RESTING AND FASTING ENERGY METABOLISM: CHICKENS

References Values calculated and adapted from the data in Kibler H. H and Brody S. J Nutrition 28:27 1944 Reprint contributed by Brody S.

Reviewers Brody S.; Kibler H H.; Landauer W ; Mitchell H H.; Winchester C F

160. METABOLIC RATES SOIL ORGANISMS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 LJ	Calc by b from 14	12 LJ	5a	23 LJ	10a
1,4 K		12 K		23 K	
2,4 5 B-O	1a	13,14 B-O	6a	26 B-O	5a
2 K	1a	15 B-O	5a	27 LJ	11a
3 J	Calc by b from 14	16 LJ	8a	27 K	a
4 5 7 9-11,13-15 17,18,21,22,24 26 30-33 35 36 K		16 K		28 B-O	5a
		17,18 B-O	7	29 34 J	4a
		19 K	a	29 34,37 K	
6 LJ	2a	19 J	4a	30 31 32 33,35	
6 K		20 LJ	9a,12a	36,38 39 B-O	5a
7 B-O	3a	21,22,24 B-O	8a	37 I	
8 LJ	4a	25 LJ	9a,12a	38 J	8a
9,10,11 B-K	4a	25 K		Pa 1	13a

Contributors (a) Macfadyen A. (b) Nielsen, C. O

References: (1) Bornebusch A. M. Rep. Brown Mem. Exp. 4 1 1950 (2) Stoeckl A. Der boden als Lebensraum. Vierteljahrschr Naturf Ges Zurich 91 , 1946 (3) Zeuthen E. Comp. rend. Lab. Carlsberg 24 399 1943 (4) Overgaard N.C. Natura Jutlandica 2 1, 1949 (5) Bornebusch C H. The fauna of forest soil, Copenhagen: 1930 (6) Konopacki M. Bull. Acad. Sci Cracovie M.n. Cl. 357 1907 (7) Vernon H. M., J Physiol. 1 910 1896 (8) Macfadyen A. 1948 (unpublished) (9) Macfadyen A., J Animal Ecology 21 87 1952 (10) Duffey, E. 1955 (unpublished) (11) Todd V J Animal Ecology 18:209 1949 (12) van der Drift J Analysis of the animal community of a beech forest floor, Wageningen 1950 (13) Krogh A. The respiratory exchange of animals and man, London: Longmans Green and Co. 1916 (14) Jansson H. L. J Sci Agr Soc. Finland 23 127 1951.

Reviewers Hutchinson G. E.; Kalle K.; Macfadyen, A.; Nielsen C O.

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